MAY 1959

Journal

VOL. 51 • NO. 5

AMERICAN WATER WORKS ASSOCIATION

The girl was a Gibson, but not the drink, in 1908, when the Dixie Cup was born to serve water—safely *(see p. 48 P&R)*

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Wolman

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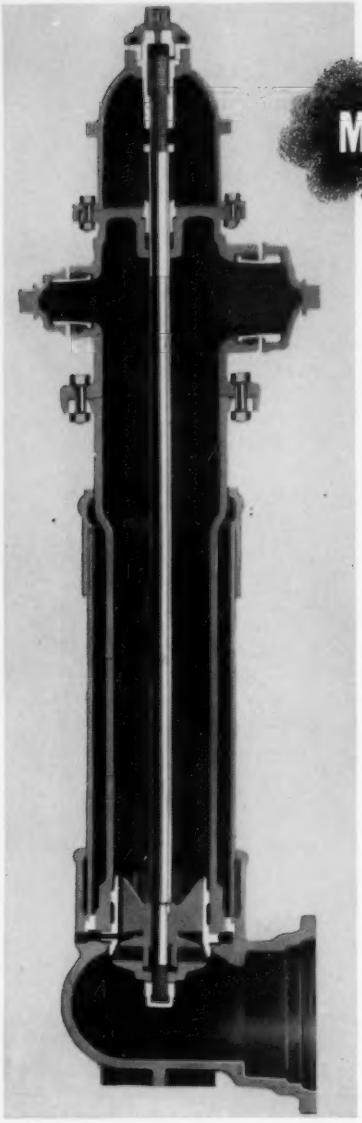

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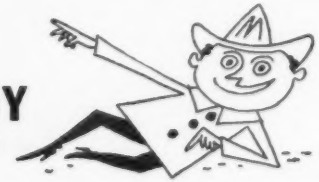

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Journal

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May 1959

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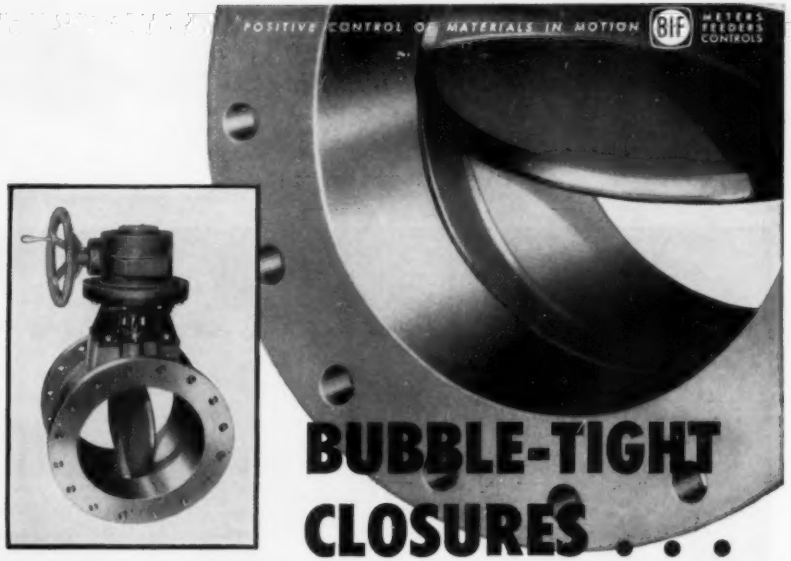

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AWWA ANNUAL CONFERENCE

San Francisco, Calif. Jul. 12–17, 1959

Official reservation forms have been mailed to all members and are returnable to AWWA.

Coming Meetings

AWWA SECTIONS

Spring 1959

Jun. 3–5—Pennsylvania Section, at Salem House, Wernersville. Secretary, L. S. Morgan, Chief, Mine Drainage Sec., 413 First National Bank Bldg., Greensburg.

Jun. 16—New Jersey Section, at Martinsville Inn, Martinsville. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Fall 1959

Sep. 8–10—Rocky Mountain Sec.

Sep. 9–11—Wisconsin Sec., Milwaukee.

Sep. 14–16—Kentucky-Tennessee Sec., Lexington, Ky.

Sep. 16–18—New York Sec., Upper Saranac Lake.

Sep. 17–18—North Central Sec.

Sep. 23–25—Michigan Sec., Saginaw.

Sep. 27–29—Missouri Sec., Kansas City.

Oct. 7–9—Chesapeake Sec., Baltimore, Md.

Oct. 8–9—Intermountain Sec.

Oct. 14–16—Iowa Sec., Des Moines.

Oct. 18–21—Alabama-Mississippi Sec. and Southwest Sec. (joint meeting), New Orleans, La.

Oct. 22–24—New Jersey Sec., Atlantic City.

Oct. 28–29—West Virginia Sec., Parkersburg.

Oct. 28–30—Ohio Sec., Dayton.

Oct. 30—California Sec., Bakersfield.

Nov. 4–6—Virginia Sec., Roanoke.

Nov. 9–11—North Carolina Sec., Durham.

Nov. 15–19—Florida Sec., Tampa.

OTHER ORGANIZATIONS

May 18–20—Symposium on Instrumental Methods of Analysis, sponsored by Instrument Society of America, at Shamrock-Hilton Hotel, Houston, Tex.

May 24–27—National Telemetering Conference, sponsored by AIEE, ISA, and others, Cosmopolitan Hotel, Denver, Colo.

(Continued on page 10)

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Coming Meetings

(Continued from page 8)

May 25–28—Annual Health Conference (regional—New York State and adjacent states), Olympic Arena, Lake Placid, N.Y.

Jun. 2–4—Appalachian Underground Corrosion Short Course, School of Mines, West Virginia University, Morgantown, W.Va.

Jun. 8–9—Short course on "Industrial Water Conservation," School of Public Health, University of Michigan, Ann Arbor, Mich.

Jun. 17–20—NSPE Annual Convention & Engineering Progress Exposition, Hotel Commodore, New York, N.Y.

Jul. 20–Aug. 14—USPHS Summer Training Institute short courses, to be given at Western Massachusetts Public Health Center on campus of University of Massachusetts, Amherst Mass.: Jul. 20–31—Basic Radiological Health; Jul. 27–Aug. 7—Aquatic Biology for Engineers; Aug. 10–14—Bioassay & Pollution Ecology. Write: Sylvan C. Martin, Regional Engr., Region II, Rm. 1200, 42 Broadway, New York 4, N.Y.

Jul. 22–25—International Conference on Waste Disposal in Marine Environment, under multiple sponsorship, University of California, Berkeley, Calif.

Aug. 17–21—Short course on "Recent Developments in Water Bacteriology," R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: Chief, Training Program, 4676 Columbia Pkwy., Cincinnati 26, Ohio (or to USPHS regional office).

Sep. 7–11—Ion-Exchange Conference, sponsored by Oak Ridge National Lab., at Gatlinburg, Tenn. (attendance limited). Write: Prof. William Rieman III, Vice-Chairman, Ion-Exchange Conference, R. G. Wright Lab., Rutgers State University, New Brunswick, N.J.

Sep. 13–18—American Chemical Society, Atlantic City, N.J.

Sep. 21–25—Instrument-Automation Conference & Exhibit, Instrument Society of America, International Amphitheater, Chicago, Ill. Write: H. S. Kindler, Director of Tech. & Educational Services, 313—6th Ave., Pittsburgh 22, Pa.

Sep. 28–Oct. 1—American Welding Society, Sheraton-Cadillac Hotel, Detroit, Mich.

Oct. 12–15—Federation of Sewage & Industrial Wastes Assns., Statler Hilton Hotel, Dallas, Tex.

Oct. 19–23—APHA Annual Meeting, Convention Hall, Atlantic City, N.J.

Oct. 19–23—ASCE Annual Convention, Hotel Statler, Washington, D.C.

Oct. 20–22—ASA National Conference on Standards, Sheraton-Cadillac Hotel, Detroit, Mich.

Nov. 29–Dec. 4—ASME Annual Meeting, Chalfonte–Haddon Hall Hotel, Atlantic City, N.J.

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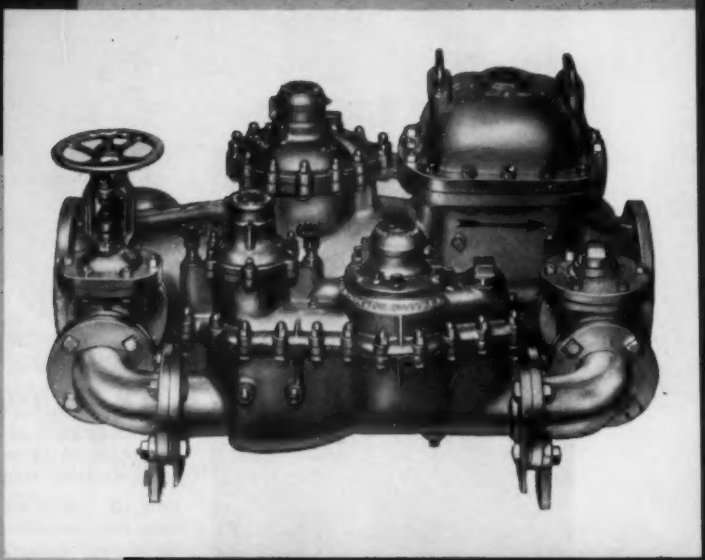

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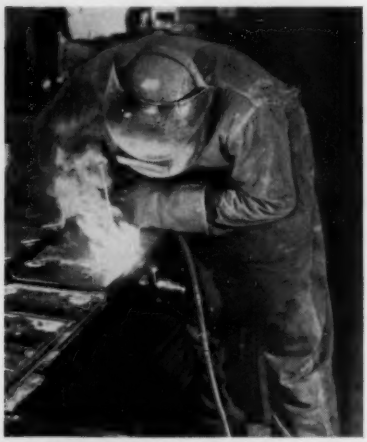
These corrosion-resistant Everdur weir plates will handle *50 million gallons* of water every day at the new Humber sewage treatment plant.



Easy fabrication. Everdur weir plates are being joined by arc welding prior to installation.

EVERDUR RESISTS CORROSION. Installations of Everdur sewage-treatment and waterworks equipment in the United States have been in service without replacement for 30 years and longer.

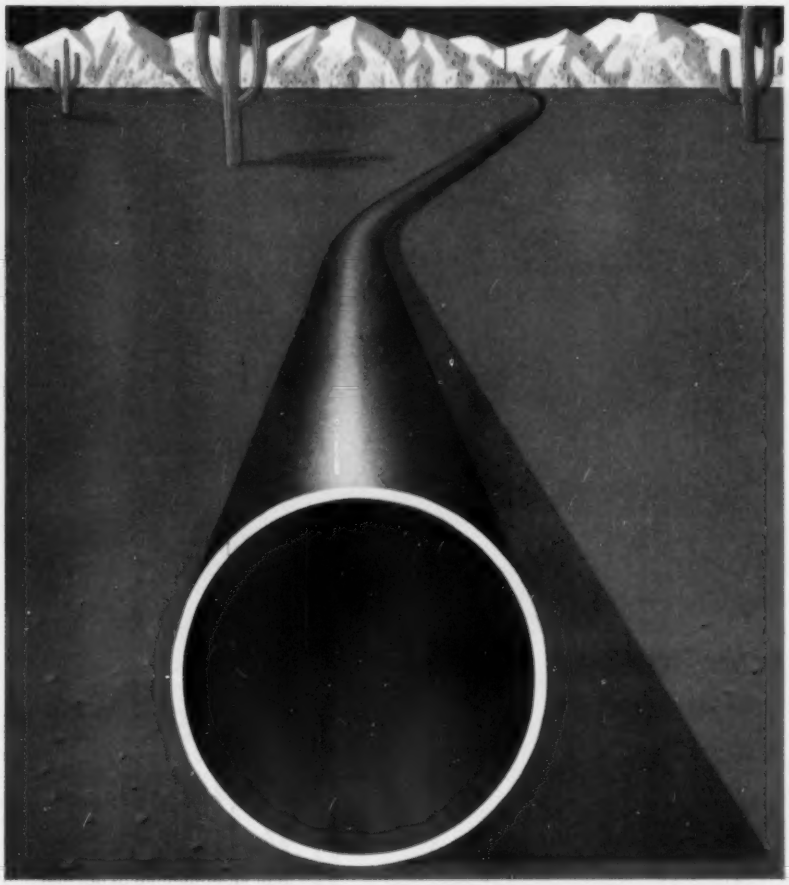
EVERDUR IS TOUGH. Everdur, Anaconda's group of copper-silicon alloys, also possesses high physical strength and resistance to wear and abrasion—so that wrought equipment can be designed with lighter weight.

EVERDUR IS READILY FABRICATED. Everdur alloys are available for hot or cold working, welding, free machining, forging and casting—and can be supplied in plates, sheets, rods, bars, wire, tubes, electrical conduit, and casting ingots.

WRITE FOR PUBLICATION E-11—or for assistance from the Technical Department in selecting the correct material for your equipment. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 8996

EVERDUR® Anaconda's Family of Copper-Silicon Alloys
MADE BY THE AMERICAN BRASS COMPANY

STRONG • WELDABLE • WORKABLE • CORROSION-RESISTANT



ALLIED CHEMICAL'S HOTLINE ENAMEL

defies 180°F. heat without sliding and −10°F. cold without cracking

Allied Chemical Hotline Enamel's resistance to both high and low temperatures, as well as its greater durability, compared to asphalt base and other coatings, has been proved by laboratory tests, and on-the-job performance for leading public utility companies. Allied Chemical Hotline Enamel is derived from coal-tar pitch, thus possessing inherent protective properties against the damaging effects of water, soil chemicals and electrical currents.

Improves protection under these specific conditions:

1. On pipe-type cables or "oil-o-static lines" which are subject to internal electrical heat from high-voltage surges.

2. Hot gas pipelines, on discharge side of compressor stations where line is above 120°F.

3. Warm, swampy areas or other places where excessive soil stress is encountered.

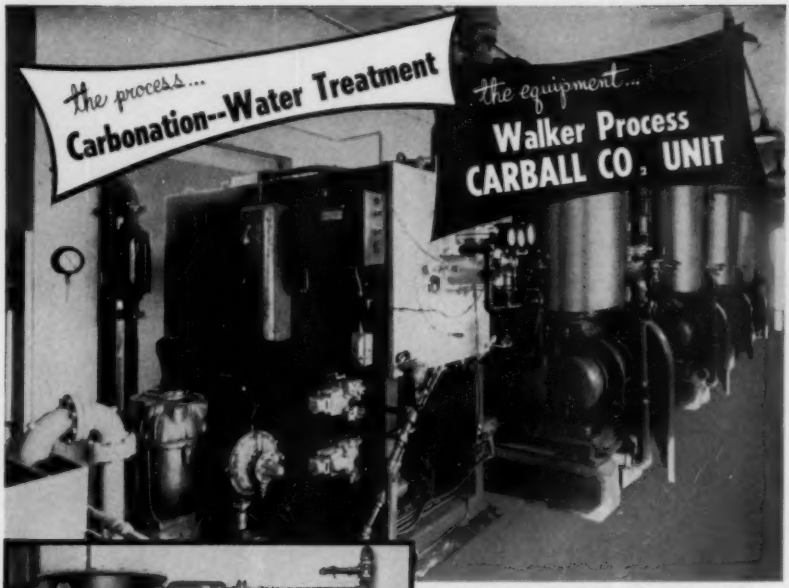
4. Areas where backfill and trenches are rough, rocky or contain objects which normally penetrate softer coatings.

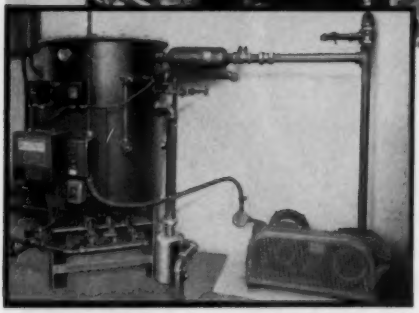
5. Pipelines (such as heated fuel lines) where temperatures are constantly high most of the time, but do not exceed 180°F. or 200°F. for short term exposure.

A staff of field service experts are at your call to offer you technical assistance that can save you maintenance time and costs. **LAST WORD IN CORROSION PROTECTION.**

PLASTICS AND COAL CHEMICALS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical





Four size 4 Carballs at Kansas City, Mo. burn either gas or oil to produce max. of 40,000 lbs. CO_2/day. Size "O" unit at left produces 570 lbs. CO_2/day for Jefferson, Iowa Water Plant.

CARBALL
CO_2 UNIT

Walker Process now offers carbonation units for all lime softening plants from the very small to the largest. Sizes range from the new "OO" unit with minimum capacity of 55 lbs. CO_2/day to the No. 4 at maximum output of 10,000 lbs. CO_2/day.

Engineers can readily provide an entire carbonation system by simply specifying the appropriate size CARBALL in combination with Walker Process SPARJER diffusers . . . . . assuring

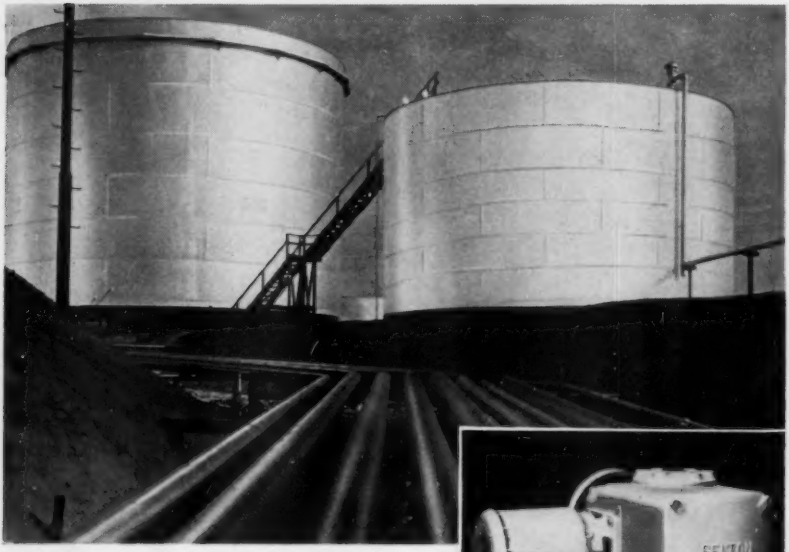
50% More CO_2
Clean, Tasteless Gas
100% Combustion
Unique Absorption Method
Economical Operation
Factory Tested Package System

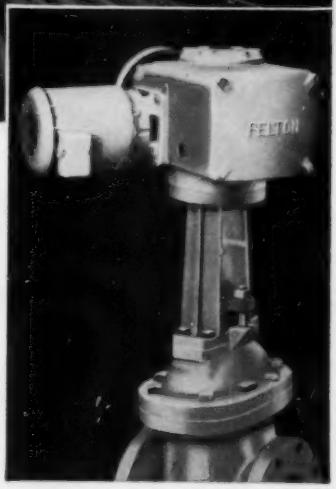
Write for bulletins 7W83 - 7W85 and 7W88

WALKER PROCESS

WALKER PROCESS EQUIPMENT INC.
FACTORY • ENGINEERING OFFICES • LABORATORIES
AURORA, ILLINOIS

Why it will pay you to insist on Pelton Valve Operators





Clear-cut reasons for the wide acceptance of Pelton Valve Operators are not hard to find. The remote control operation feature produces significant time and labor savings, while the manual control can be utilized in emergency operation. By means of self-locking worm gear sets and a planetary gear system, both the remotely controlled motor drive and the local handwheel are directly connected at all times to the output load. This permits the handwheel to be continually engaged, yet prevents rotation during periods of electrical operation.

The Pelton Valve Operator requires no clutching—either manual or automatic. Excess torque protection is also provided. These exclusive features insure complete safety to operating personnel and plant equipment.

The Pelton Valve Operator may be used with a variety of valve types and is adaptable to a completely automated system as well as simple pushbutton control. At present three motorized drive models of outstanding dependability provide up to 35,000 lb of thrust for lifting requirements and as much as 6600 in-lb of torque. Larger sizes will of course be built to fill specific requirements.

For our new illustrated Bulletin No. 49, write Pelton Division (B-L-H), 2929 Nineteenth Street, San Francisco 10, Calif.

Pelton Division San Francisco, Calif.

BALDWIN • LIMA • HAMILTON

Hydraulic turbines • Valves • Governors • Centrifugal pumps

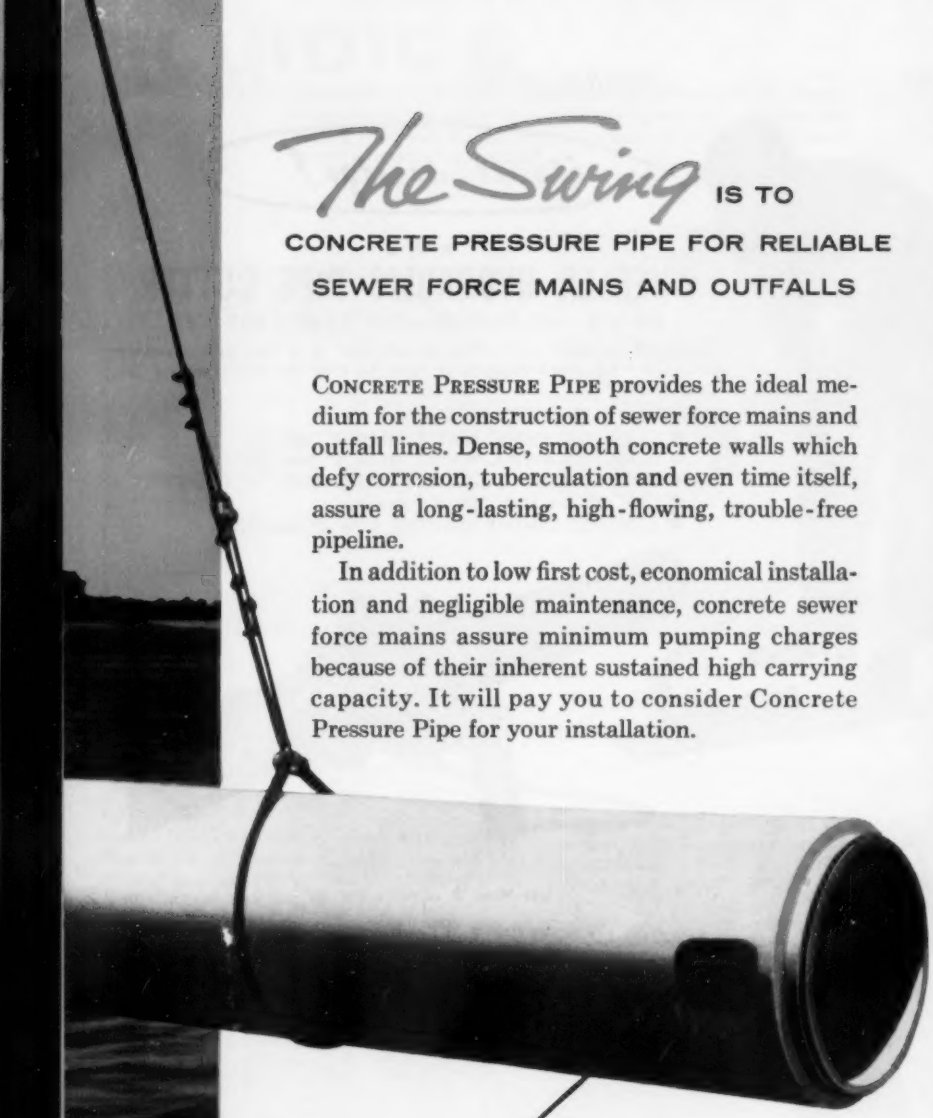
BALDWIN BLH LIMA-HAMILTON

The Swing IS TO

CONCRETE PRESSURE PIPE FOR RELIABLE SEWER FORCE MAINS AND OUTFALLS

CONCRETE PRESSURE PIPE provides the ideal medium for the construction of sewer force mains and outfall lines. Dense, smooth concrete walls which defy corrosion, tuberculation and even time itself, assure a long-lasting, high-flowing, trouble-free pipeline.

In addition to low first cost, economical installation and negligible maintenance, concrete sewer force mains assure minimum pumping charges because of their inherent sustained high carrying capacity. It will pay you to consider Concrete Pressure Pipe for your installation.

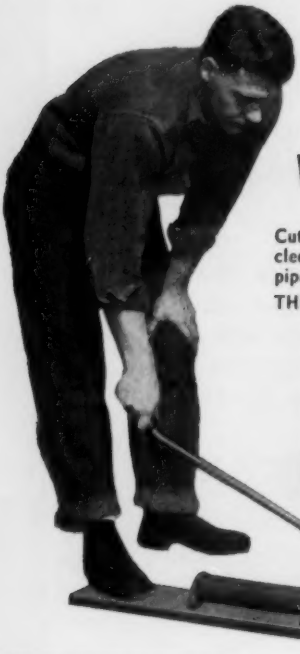


WATER FOR GENERATIONS TO COME

Concrete PRESSURE Pipe

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION

228 N. LA SALLE STREET, CHICAGO 1, ILLINOIS



it's a snap!

with a

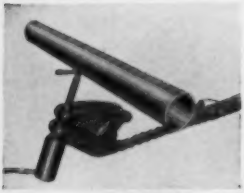
WHEELER HYDRAULIC PIPE CUTTER

NO VISE — NO TURNING — JUST SQUEEZE AND POP!

Cutter can be used in a ditch to cut pipe in a line with minimum clearance. All that's required is room to wrap the chain around the pipe.

THE HYDRAULIC MODEL CUTS —

- CLASS 150 AWWA WATER MAIN 4" thru 12"
- CLASS 250 AWWA WATER MAIN 4" thru 12"
- CEMENT LINED CAST IRON WATER MAIN 4" thru 12"
- STD. OR XH SOIL PIPE 6" thru 15"
- ASBESTOS CEMENT PRESSURE PIPE 6" thru 10"



— less than 2 minutes per cut —
a one man operation.

PIPE LINE EQUIPMENT

JOSEPH G. POLLARD CO., INC.

PIPE LINE EQUIPMENT

PIPE LINE EQUIPMENT

Place your next order with POLLARD

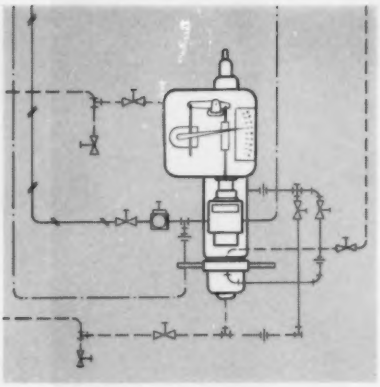
If it's from POLLARD ... it's the Best in Pipe Line Equipment

NEW HYDE PARK • NEW YORK

Branch Offices: 964 Peoples Gas Building, Chicago, Illinois
333 Candler Building, Atlanta, Georgia

FLUIDICS

is a Pfaudler Permutit program providing a modern, imaginative approach — plus the specialized materials and equipment — for handling and processing and controlling more profitably the liquids and gases which are the lifeblood of our manufacturing economy.



FLUIDICS AT WORK

New pneumatic transmission system more accurate, more dependable

The diagram shows a typical setup for the new Simplex system for transmitting rate of flow and loss of head to a receiver.

Rate of Flow

The new Type PN transmitter combines the exceptional accuracy and range of a differential converter operated by a mercury float with the traditional dependability of pneumatic transmission.

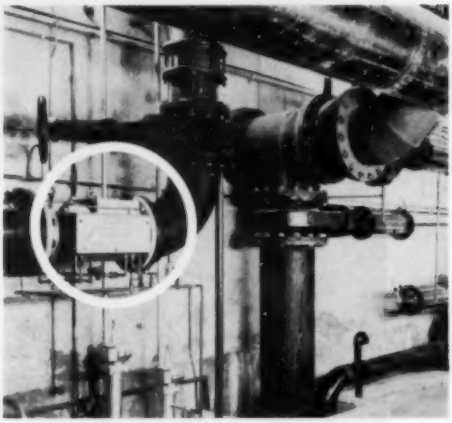
The transmitter consists of a differential converter which extracts the square root flow function from a primary and then positions a pneumatic motion transmitter. The transmitter produces a pneumatic 3 to 15 psig linear signal. A booster pitot diaphragm in the motion transmitter insures a low lag coefficient and fast transmission.

Besides getting a linear signal without using supplementary pneumatic relays, this new unit gives you point accuracy over wide ranges of flow with minimum differentials. The booster permits accurate transmission over long distances with minimum lag.

Loss of Head

A Type TD transmitter gives accurate readings to within ±1%. It uses no stuffing boxes or relay valves, so both installation and maintenance are simple and economical.

Connected to Simplex Pneumatic Gauges, this new system should give long years of accurate, dependable, trouble-free service.



FLUIDICS AT WORK

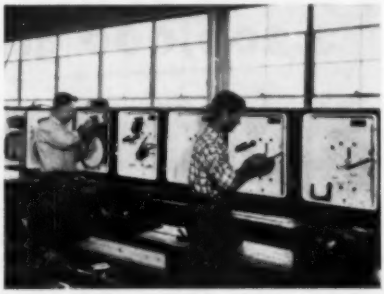
Modulair Flow Controller installs as easily as a piece of pipe

So simple is this new pneumatic rate-of-flow controller, you can install it in about the time it takes to install a piece of pipe.

The differential producer and the modulator lie in a single housing. The actuator is entirely enclosed in a case which mounts directly on the housing.

Result: No complicated piping or drain system to install and maintain.

For a bulletin giving complete specs and performance data, write to our Simplex Division, Lancaster, Pennsylvania. Ask for Bulletin 951.



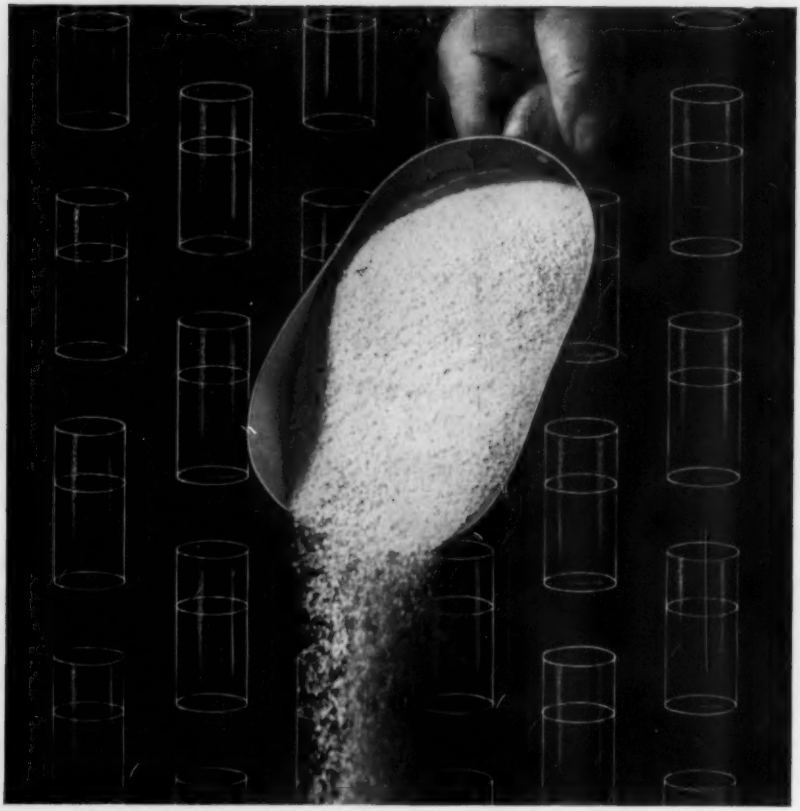
Fast, dependable delivery insured by new plant

This is the new $2,000,000 home of our Simplex Division . . . an ultra-modern plant designed from front to back to give you fast, dependable service on valves and meters. New manufacturing techniques, updated assembly lines and ample manufacturing capacity and a complete staff of skilled workers have all been planned around the single objective of getting your orders to you on time and built to your exact specifications.

SIMPLEX®

a division of PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . .
the science of fluid processes



One pound of HTH chlorinates 3,200,000 glasses of water*

. . . but the economy and effectiveness of HTH are only part of the story! You should also consider the convenience of this easy-to-store, and easy-to-use *dry* chlorinating product.

Consider, too, HTH's wide range of applications. Wherever germs, fungi or bacteria threaten—in pipe lines, reservoirs, wells, filtration equipment, as well as during emergency flood conditions—you get fast, dependable chlorination with HTH.

HTH, containing 70% available chlorine, is made in granular and tablet form. Both products are proved by over 25 years of successful service in almost every phase of water treatment. Check your supply house or write us today.

*0.5 ppm available chlorine treatment

HTH

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CHEMICALS DIVISION • BALTIMORE 3, MD.

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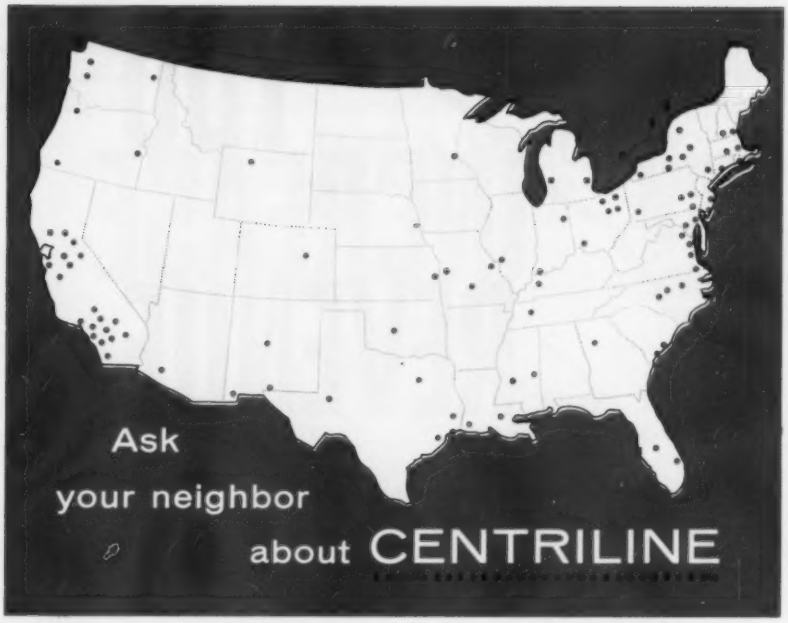


Spotted on this map are some of the places that have been served by the Centriline Process

Chances are that one of your colleagues has rejuvenated some of his city's piping by Centriline reconditioning. Now here's your chance to find out.

Briefly, this process smoothly lines piping—*in place*—with cement-mortar, creating a pipe-within-a-pipe. This vastly increases carrying capacity, stops leakage, prevents corrosion and tuberculation, and prolongs pipe life indefinitely. Pressure goes up, pumping cost goes down, and there's no need to disturb traffic to replace mains. Over 6,000,000 feet of piping, from 4" to 144" diameter, have been treated by Centriline. *Ask your neighbor.*

Write today for a list of nearby officials whose cities have cut inconvenience and costs with this pipe-saving process. Hear what they have to say about Centriline. Then write or call us. We'll be glad to show you how Centriline can help *you* solve the problems of pipe reconditioning in place.

CENTRILINE CORPORATION

A Subsidiary of Raymond International, Inc.

140 CEDAR STREET • NEW YORK 6, N. Y.

Branch offices in principal cities of the United States, Canada, and Latin America.

YOU INCREASE REVENUE

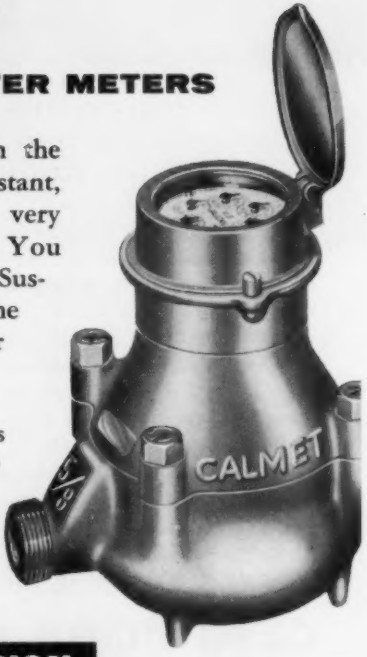
WHEN YOU STANDARDIZE ON

CALMET

PISTON-TYPE WATER METERS

With rugged CALMETS in the lines, you are assured of constant, care-free operation with a very minimum of maintenance. You also know that CALMET'S Sustained Accuracy provides the maximum revenue to your community.

For information and quotations WRITE or WIRE TODAY to



WORTHINGTON

CALMET METER DIVISION

2301 SO. MAIN
FORT WORTH, TEXAS

WHICH SIZE WILL SOLVE YOUR PRESSURE PROBLEMS?

Satisfactory water pressure through suitable storage facilities can be accomplished economically by calling on Graver. Graver fabricates and erects all sizes of elevated water tanks—in standard sizes ranging from 25,000 to 3,000,000 gallons—in special designs to fulfill unusual needs. Should a standpipe, a steel reservoir or a pump suction tank best solve your problem, Graver builds these, too. It pays to call on Graver's versatile craftsmanship!

GRAVER TANK & MFG. CO.

DIVISION—UNION TANK CAR COMPANY

Plants and Offices Across America

EAST CHICAGO, INDIANA

GRAVER

what price water?

WHAT PRICE WATER? is a 12-page, 4x9-in. booklet that calls to the attention of the reader the real value of public water supply. Comparing 1940 prices of a number of other common items with today's, it also presents a comparison of the 1940 costs of water works facilities with present ones as an indication that water rates must be boosted. Designed to fit in a standard No. 10 business envelope, the booklet sells at prices ranging from 10¢ to 2½¢ per copy. Imprints of your name and address as well as your rate per thousand gallons or cubic feet can be provided on lots of 500 or more. Ask for sample.

Willing Water Jewelry

Since their introduction in 1954, the Willing Water jewelry items have been most popular as awards, gifts, and good will builders. Presenting a blue-faced Willie in full stride, the emblem has made a hit as a lapel button as well as a decoration on a number of jewelry items. Included in the list of items now available are:

AW-1	Lapel Emblem (screw-back)	$ .75
AW-2	Lapel Pin (joint pin & safety catch)	.75
AW-3	Key Chain (spiral mesh chain and spring-lock holder)	1.25
AW-5	Zippo Cigarette Lighter (brush finish, boxed)	3.15
AW-8	Shortie Tie Clip (rhodium plated alligator clip)	$1.85
AW-9	Money Clip (rhodium plated)	2.75
AW-10	Cuff Links (rhodium plated disks)	4.50
AW-11	Earrings (screw type)	2.50

Willing Water Service Buttons

The popularity of Willing Water lapel emblems has led to the design of a special button for recognition of tenure. The design shown at the left was prepared on the request of the Alliance, Ohio, Water Department, which now uses the service buttons. It is now available to you, with your company name engraved on it. Minimum order is 25 buttons or pins. On such an order a die charge of $17.50 is made for inserting your company name. The pins (with joint pin and safety catch) or buttons (with screw-back) are priced as follows:

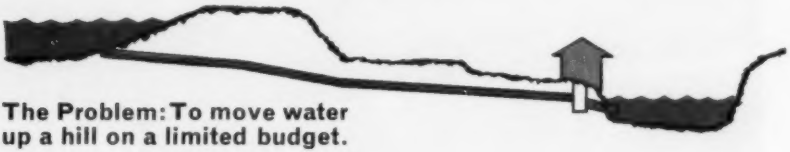
Bronze	$1.00	10K Gold	$5.25
Sterling	1.50	14K Gold	6.75
Gold filled	2.00		

The minimum quantity (25) may be assorted as to years of service and as to metal used. Please specify clearly the number of each type required with pins (for female employees) and with screw backs.

AMERICAN WATER WORKS ASSOCIATION

2 Park Avenue **New York 16, N.Y.**

the problem...



The Problem: To move water up a hill on a limited budget.

The Project: New raw water line for the town of Franklin, Tennessee.

The Engineer: HARRY HENDON & ASSOCIATES, Birmingham, Alabama.

The Solution: Specifying pipe to AWWA Standard C 302-57 as an alternate.

The Result: A saving of $4,689.22 on 2200 feet of 18" CEN-VI-RO Reinforced Concrete Water Pipe that will still be delivering water for generations to come.

Cen-Vi-Ro Pipe... engineered and made to your specifications... serves you better. When your job calls for concrete pipe, call Concrete Pipe Division, Vulcan Materials Company, Atlanta, Georgia.

CONCRETE PIPE DIVISION

VULCAN MATERIALS COMPANY

O. Box 6226, Station H, Atlanta, Georgia • JAckson 4-6244

The raw water's loaded with problems, but

Dubuque gets

100-hour filter runs with Permutit Precipitators

Influent at Dubuque's new Eagle Point water treatment plant is loaded with iron, manganese and a hardness of 320 ppm. When you're working with raw water like that, the chances for long filter runs would ordinarily be slim.

Yet two vertical Permutit *Precipitators* hold their blankets effectively even while handling the precipitates from this highly mineralized raw water. The effluent they produce is so low in floc-carryover that very little load is placed on the filters. Result: Getting 100-hour filter runs is no problem at all. Precipitation is complete; there's no troublesome lime build-up on the filter sand.

The high efficiency of the *Precipitator's* unique upflow sludge blanket has shown up fast in low operating costs for the Eagle Point plant. Long filter runs mean less treated filter-wash water is used, hence pumping and chemical costs are both reduced.

Permutit can help you come up with the right answer to your community's water problems. Just contact the Permutit office listed in your phone book. Or write to us directly. The Permutit Company, Dept. JA-59, 50 West 44th Street, New York 36, New York; or Permutit Company of Canada Ltd., Toronto 1, Canada.

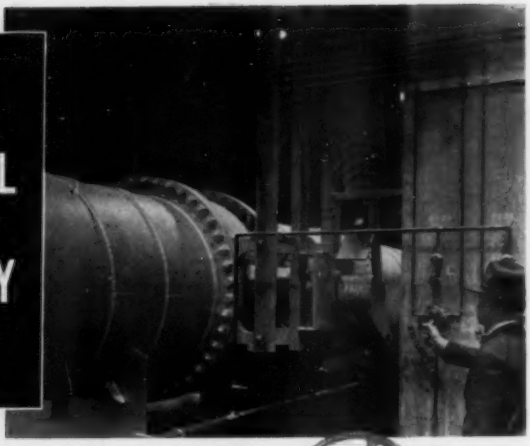
Two Permutit Precipitators treating 12 million gpd at the Eagle Point Water Plant, Dubuque, Iowa. Plant designed by Consoer Townsend & Associates, Chicago, Ill.

PERMUTIT®

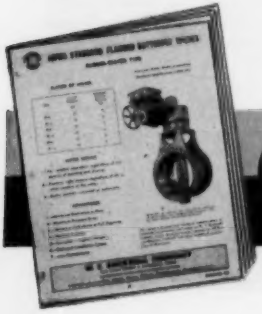
rhymes with "compute it"
a division of PFAUDLER PERMUTIT INC.
Water Conditioning
Ion Exchange • Industrial Waste Treatment

at the Massena, N. Y., intake of the St. Lawrence Project

they've installed ROCKWELL AWWA BUTTERFLY VALVES



Yes, five 48" diameter Rockwell valves passing some 40 million gallons of water daily. Two of these valves at the canal intake are equipped with extended stems and worm gear handwheel units for remote control; the three valves in the power plant are equipped with hydraulic cylinders and 4-way control valves. All have Rockwell's exclusive Wedge-Lock rubber seat insert for drip-tight shutoff.



There are many such successful Rockwell valve installations for water applications. Bulletin 581 tells why.

ROCKWELL SINCE 1888 BUILT

BUTTERFLY VALVES

W. S. ROCKWELL COMPANY

2609 Eliot Street, Fairfield, Conn.

USE NORTHERN GRAVEL
for
RAPID SAND FILTER

FILTER SAND SPECIFICATIONS are carefully laid out. The Effective Sizes and Uniformity Coefficients used by Consulting Engineers and also recommended by the American Water Works Association are the result of long years of research and experience.

The Northern Gravel Company is equipped to give you prompt shipment whether it be one bag or many carloads, exact to specification. Filter sand can be furnished with any effective size between .35 MM and 1.20 MM.

CHEMICAL QUALITY of the filter sand is also important. It must be hard, not smooth and free of soluble particles. This requires perfect washing, and grading facilities. We have every modern device for washing, drying, screening and testing.

FILTER GRAVEL supporting the Filter Sand Bed must be, in turn, properly graded to sizes calculated to support the Filter Sand, and be relatively hard, round and resistant to solution.

The new Northeast Station in the City of Detroit, recently completed, is one of the major projects included in the water department's expansion program. The Northern Gravel Company furnished 120 carloads of filtering materials for the 48 rapid sand filters incorporated in this plant.

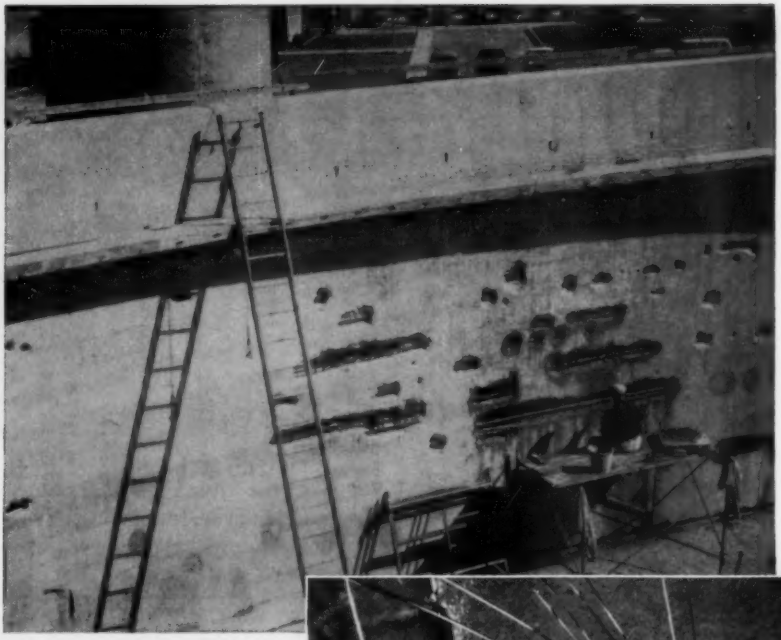
Northern Gravel has no equal in facilities and our reserves of both sand and gravel are inexhaustible. Northern Gravel Company has been in business over 40 years. We guarantee uniformity of products and our records enable us to duplicate your requirements on short notice. Our location is central and we have commodity rates in every direction.

NORTHERN GRAVEL COMPANY

Muscatine, Iowa

P.O. Box 307 **Phone: Amherst 3-2711**

CONCRETE NEEDS CORROSION



Damage caused by sub-surface corrosion of steel reinforcing rods is shown in this view of tank interior.

Close-up of pre-stressed tank exterior shows large sections of gunite which were forced from wall by corroding wires.

PROTECTION, TOO

Case history of sub-surface corrosion shows porosity of concrete

When the Koppers Contract Coating Department was called in by an East Coast chemical processing firm for its recommendations on waterproofing sea-water treatment tanks, it found the conditions shown on the facing page.

Some tanks, up to 200′ in diameter, were formed of 16″-thick reinforced concrete. Although various coating systems had been tried in attempts to stop water migration, the concrete was spalled away in many areas by sub-surface corrosion of reinforcing steel.

Other tanks of the pre-stressed type at this same location were also attacked by corrosion in less than two years. Pre-stressed wires around the tank had failed due to corrosion caused by water migration through the walls and from the outside, through as much as a 1″ protective layer of gunite.

After repairs to the concrete, the walls of the tanks are being coated with Bitumastic protective coatings by the Koppers Contract Coating Department. The proven waterproofing ability of coal tar, principal ingredient of Bitumastic coatings, protects concrete against the penetration of water and subsequent corrosion attack on imbedded steel. And the thick film characteristics of Bitumastic coatings make them long-lasting, too. For the tough jobs, it pays to specify the unequalled corrosion protection of Bitumastic protective coatings.

TAR PRODUCTS DIVISION
KOPPERS COMPANY, INC.

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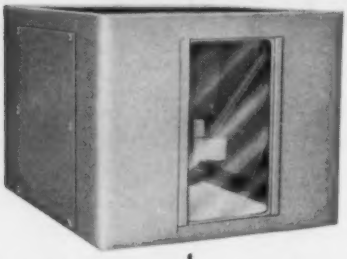

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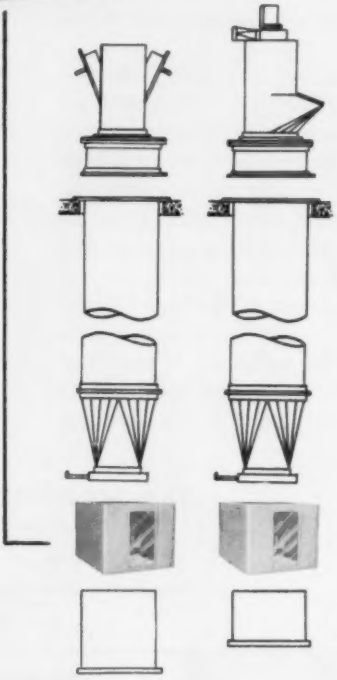

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Philosophy for Water Utility Managers

Abel Wolman

A contribution to the Journal by Abel Wolman, Prof. of San. Eng., Johns Hopkins Univ., Baltimore, Md.

NOT many months ago the Ad Hoc Committee on Public Information of AWWA presented a report (*1*) reflecting in detail on the state of water utility development in America. In this report an appraisal was made of the difficulties now encountered in providing the best water service to the rapidly growing communities of the US and Canada. Among the obstacles to providing maximum quality service, high significance was placed on the deficiencies of management, the public, and technologists. As a matter of fact, the difficulties noted and the campaign suggested for resolving them and moving toward more positive and prompt accomplishments give one the impression of a severe indictment of water utility management. The emphasis on the indictment aspect of so much of the report was clearly not intended. Undoubtedly, the committee was anxious to set forth explicitly the areas of deficiency in order to lay the groundwork for future management practice and attitude. As an exposition of the problem confronting professional water utility people, the report is one of the best at present available in the literature.

The committee lists as the major roadblocks to improvement in water service: lack of public appreciation, lack of realization of the problem by water utility people themselves, and lack of prompt planning for growth. As these roadblocks are particularized, there results a plan of campaign which is intended to be applicable to local water utility managers and personnel, to engineers and others with specialized training, to voluntary agencies, and to manufacturers of water works equipment and supplies.

Before attempting, therefore, to evolve a philosophy for water utility managers, one may well spell out the setting in which such a philosophy may be expected to prevail. This setting likewise has been briefly reviewed, at least in part, by AWWA (*2*) and may be paraphrased in the following terms:

1. Some 18,000 water utilities function in the United States, each domi-

nantly controlling the present and future welfare of the community.

2. Water for domestic, commercial, and industrial supply is vital to urban communities.

3. Adequate water supply facilities are absolutely essential to the growth of the country.

4. A countrywide survey of water utilities, both publicly and privately owned, indicates that:

a. One of five is deficient in supplies.

b. Two of five are deficient in transmission capacity.

c. One of three is deficient in pumping capacity.

d. Two of five are deficient in treatment capacity, and very many need treatment facilities not now installed to provide the quality product desired by consumers.

e. Ground and elevated distribution storage shows deficiencies of 29 per cent and 43 per cent, respectively.

f. Distribution system improvements are required in 57 per cent of the water systems.

g. Many systems need to undertake measures to place them on an improved business basis.

5. Present systems are deficient to meet present demands. Those demands are high and will continue to grow. Water systems must be kept in balance with those growing needs.

6. Planned water utilities and budgeted water system improvements totaled over $600,000,000 for 1958.

7. Water works projects needed to provide balanced systems to meet the growing needs of each community will cost billions of dollars.

8. Most local water supply system improvements can be undertaken and financed locally and will provide long-term public benefits without creating inflationary pressures.

Changing Times and Requirements

In addition to the above concrete characteristics of the present public water supply scene, even the amateur observer has become aware of the changing structure and the behavior of the people of the United States. This country is now confronted with 15,000 local governments, operating in 174 metropolitan areas, which include their surrounding cities of 50,000 or more population. As a matter of fact, most of the nation's increase in population since 1950 has occurred in the suburban areas surrounding the central cities. Historical solutions and principles governing water system development have not always proved to be appropriate to the new geographical and cultural developments. If it is recalled that about 60 per cent of the nation's population now resides within such areas, one can no longer assume that the hand-to-mouth development on an inner-core urban basis will always work. The trend here delineated gives no promise of cessation. It must be accepted, therefore, as the kind of development within which the water utility manager must function. A recent congressional committee report (*3*) aptly describes this new urban pattern as "sprawling, still indecisive, and transitionally inefficient—but definitely new. . . . The process [of urbanization] has by no means run its course—indeed it promises to accelerate under the impact of the new federal interstate highway system which will build 6,700 mi of limited-access freeways in United States urban areas. The further explosion of our cities along these major highways—already experienced in Boston and some other cities—is a foregone conclusion."

The utility problem posed by exploding areas, ribbon development,

"skip-jump" subdivisions, and complete disregard for political boundaries represents one of the major challenges of the past century to the majority of water utility managers. Past attempts to fit these curious growth patterns into the straitjackets of municipal design and finance have been singularly ineffective.

Howson dramatized this point clearly when he listed seven salient questions now urgently requiring answers, within this new setting (*4*):

1. How many people will be served by public water systems 25 years from now?
2. How much of a growth will there be in water requirements in the next 25 years?
3. Is there a real problem now, or a possibility that a water shortage will develop in the future, or will there be an adequate supply for all necessary purposes?
4. How far can a city afford to go for its water supply?
5. Is pollution of water sources to be permitted to jeopardize the public water supplies, and whose business is it to see that pollution is kept under control?
6. How can water utilities, the most essential of all community services, increase the public appreciation of their contributions toward better living?
7. Finally, as the solution of all water problems depends upon adequate and sound financing, on what basis should water charges be computed?

As Howson pointed out, all of these questions are simply repetitions of the familiar questions to which water utility managers have been perennially exposed. Certain fundamental differences in solutions appear, however, in attempts to respond to the challenge of these questions. The country now supports millions of people who stem from urban areas and who for half a century have become accustomed to the services which publicly and privately owned utilities have provided. With their movement into areas that have larger lot sizes, less accessibility to water sources, characteristics of fringe growth, and developments so often controlled by cheapness of land and by rapidly extending highways, new modifications of old problems emerge. Regardless of these circumstances, people are unwilling to accept primitive facilities and are not satisfied with arguments that modern engineering cannot and perhaps should not meet their desires. The water utility manager, therefore, if he has not already done so, must find answers to these problems rather than maintain a stoical *status quo*. Such an orthodoxy of position deprives him of maintaining or acquiring the imagination and leadership which the community undoubtedly expects of him or of someone who will replace him.

One is aware that such reorientation implies redefinition of purpose, of engineering method, of fiscal evaluation and adjustment, and of the gradual evolution of novel experimental approaches to solving all of these problems.

Responsibilities of Manager

In the light of these observations on the present way of life of the American people, it is now possible to define somewhat more specifically the areas of a manager's responsibility. By such definition, a philosophy, as a guiding principle, will emerge.

1. *Appraising the Future*

Perhaps the major obligation of a water utility manager is to stand aside from the present and look at arm's length at the immediate and the remote future. He must be in a position

to accept the emergency scene and its strange demands on and in relation to water service. It is in this obligation that the widest range of his imagination may be demonstrated. In viewing such a vista, he must escape the heavy hand of the orthodox past, except where it offers him a sound basis for imaginatively exploring the future. An imagination, tempered by the realities and practicalities of the marketplace, is the area in which perhaps his greatest potential lies.

Some examples of such pressing questions are here noted. The water-consuming habits of people and industry have not yet been completely explored and certainly not measured in detail. The literature is filled with assumptions of consumer behavior and with parallel assumptions as to the part which the water system developer may play in meeting or combating this behavior. Committees of water utility men are increasingly exposing these areas of assumption to quantitative diagnosis and suggesting, furthermore, that sound appraisal of the underlying bases of these assumptions should be made in the field as rapidly as possible.

One such area, of course, is the familiar suggestion that summer sprinkler necessities cannot be met, except at undue expense in distribution system reinforcements. Is this true—and if true, what are the parameters and what are their quantitative features? Studies in this area alone are amazingly meager and fragmentary.

Much has already been made of the necessity for a new look, both broad and deep, at the whole fiscal basis for water system development. Case histories abound of water utility managers who, through ostrich-like appraisals of current problems, have retarded development and have in fact invited chaotic development. Much of this attempt to stem the tide of growth (which, incidentally, still remains a major indoor sport for some water utility managers) has its origin in the desire to maintain a tax base within municipal boundaries, to resist growth beyond the boundaries, to pursue rules of extension which have outlived their appropriateness, to gain little or no support from regulatory agencies for a reappraisal of the problem, and to cling to the eternal hope that somehow or other the future will be more peaceful and familiar in demands than the immediate past.

The history of almost every major water area in the United States presents one or more of the above characteristics. It would be interesting on some future occasion to determine why this policy of resistance has so persistently prevailed. The literature has long made available to the water utility manager alternative fiscal principles dating back to the proposals by Snow in New England (*5*), by Morse and Wolman in the Maryland area (*6–8*), by the Joint Committee of the ASCE and the Section of Municipal Law of the American Bar Association (*9*), and more recently by Richard Hazen (*10*). Each of these reviewers of fiscal policy has emphasized for many years the necessity of imposing part of the cost of water utilities on property owners, whose property is enhanced by the availability of water and sewer service, whether or not they immediately use the service. In addition, much water distribution extension in metropolitan areas is geared to future land development.

Population growth, from the geographic standpoint, in the last 20 years makes new reference to these principles virtually a necessity for every water utility manager. This is particularly

true where necessary design and construction for the future consumer impose an undue burden upon the present user, if capital costs are recaptured only by means of consumption charges. True regional water supply development, so characteristic of our rapidly evolving urban areas, cannot proceed within the confines of fiscal perspectives of the old municipality. The mere doubling of water rates to outside consumers by no means goes to the roots of this issue, as the last 10 years' experience well demonstrates.

From a political standpoint, it is equally clear that the future will become more complicated rather than less. If the manager hopes to see in the future less prospect of psychological disturbance in meeting his responsibilities, he is foredoomed to disappointment.

2. *Meeting New Problems With New Solutions*

In the areas of design, construction, operation, and maintenance, the water supply profession has an enviable record. That record is likely to be sullied if the profession does not move with great rapidity to forestall the deficiencies in all these areas which new growth is creating at high speed. Here, again, the manager is confronted with the necessity of an adjustment in sights. The ingenuity required in these functions is no less striking than in the solution of fiscal and economic problems of utility service.

Some water purveyors are already demonstrating, not only an awareness of, but also imaginative answers to these growth problems. Under both private and public ownership, systems are being designed and constructed, which, in fact, skip geographical sections, through development of satellite sources and distribution systems, geared to be linked through appropriate connection with existing systems as time and as growth may later demand or justify. Even rural areas are now being served with economy in the Washington Suburban Sanitary District.

3. *Influencing the Public*

There are distinguished examples of water utility managers who have demonstrated superb capacity for public relations. They are unfortunately few in number. A recent review (*11*) of this situation led to the conclusion: "it seems that the problems of management and administration have not been a serious concern of the water utility profession."

In other words, great concentration and successful implementation have gone into the utilization of material resources and relatively little into the relationship of such material resources to human problems.

The skill which some have shown in bridging this gap apparently has not infected large numbers of water utility managers. The almost universal desire to avoid political entanglement has virtually precluded many excellent technologists from taking a desirably effective position in the community. Politics remains to most an anathema, rather than the art of governing people. In this essential art in a democracy, the water utility manager must find a significant daily part.

4. *Inspiring Personnel*

No successful management operation results from only the manager himself. Success is peculiarly the result of total organization. It is not the simple drafting of an organization chart, but is the characterization of an indefinable

spirit of public service. Indefinable as that spirit is, it is quickly apparent in almost any contact with water departments or companies. The skill of a manager in exercising a pervasive influence in the entire organization of public service is as important as it is elusive and rare.

5. *Appreciating the Need for Professional Assistance*

Increasingly the problem of water service will create problems which require the assistance of professionals in other fields. In law, for instance, the skillful guidance of the lawyer, more and more familiar with water service, becomes a major necessity to the manager. Again, awareness of the problems to be encountered, the issues to be met, and the preparations for such encounters is being rapidly extended. They impose, therefore, additional responsibilities which historically were either simple or nonexistent.

Lifeblood of the Community

One cannot review this entire scene without a strong sense of the difficulties involved in any water utility manager's life. A rehearsal of the vices which he has developed over the years of his experience and of the virtues which the future may demand of him can only lead to a feeling of complexity and perhaps even of frustration.

In spite of this, however, the reflective manager will undoubtedly emerge from the present crises with a broader concept of his responsibilities and a deeper consciousness of the skills required for their implementation in order to make the most successful contribution to society. No simpler definition of a philosophy appears either possible or desirable. If such a philosophy must be firmed up in simple terms it has in fact been anticipated by AWWA in the slogan: "Good water, the lifeblood of your community." The slogan itself virtually defines the limitless nature of the obligations of the water utility manager.

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Lead Dissolution From Red-Lead Paints in Water

D. A. Fraser and L. T. Fairhall

A contribution to the Journal by D. A. Fraser, Chemist, Occupational Health Program, Bureau of State Services, USPHS, Cincinnati, Ohio, and L. T. Fairhall (deceased), formerly Scientist Director, USPHS.
This is an abridged version of a paper submitted for publication in Public Health Reports *and was prepared by Harry A. Faber, Research Coordinator, Div. of San. Eng. Services, USPHS, Washington, D.C.*

CONCERN increases over the amount of lead taken into the body daily as it becomes more and more apparent from analyses of foods, air, and water that each source contributes a daily burden of lead to the body. The maximum noncumulative daily body burden has been determined to be 0.5 mg of lead. Lead intake from sources other than water dangerously approaches this permissible maximum. If it is found that any one of these sources contributes an undue amount of lead, then efforts should be made to indicate the source and suggest a remedy.

In view of the extensive industrial use of red lead and red-lead paints and the hygienic significance of lead compounds, it is remarkable that so very little is known regarding the solubility of these materials in water. According to Friend (*1*), red lead is "practically insoluble in water." The only solubility value available in the literature is that theoretically derived by Glasstone (*2*) from electrode potential measurements.

The purpose of this investigation was to study the solubility of red lead experimentally and to determine the extent of dissolution of lead by water in contact with red-lead–painted surfaces. In the paint film study, three types of red-lead paint were investigated: [1] linseed-oil base, conforming to Federal Specification TT-P-86a, Type I; [2] phenolic base, conforming to Federal Specifications TT-P-86a, Type IV; and [3] vinyl base. No federal specification for vinyl-base paint was available, and the composition of the paint used is therefore given in Table 1.

Procedure

Glass plates were cut to measure 3 × 6 in. from stock having a thick-

TABLE 1

Composition of Vinyl-Base Red-Lead Paint

Component	Amount *wt per cent*
Red lead (Federal Specification TT-R-191, Type I, Grade C)	23.70
Aluminum stearate	0.10
Vinyl resin	16.35
Tricresyl phosphate	1.64
Toluene	25.31
Isopropylacetone	25.31
Diethylene glycol monoethyl ether* (low specific gravity)	7.59

* Carbitol; a product of Union Carbide Corp., New York, N.Y.

ness of 0.3 cm. Areas were measured and marked off to total 100 sq cm on each plate. The plates were then washed and finally cleaned with nitric acid and distilled water. They were then dried and painted to the desired area, and the paint film was allowed to dry. In the case of oil-base paints, various drying times were tested. The drying time of the phenolic- and vinyl-base paints was less important, as drying consists principally in evaporation of the solvents (*3*).

The painted plates of either glass or metal were placed in tall 1-liter beakers and 500 ml of either distilled water or the desired salt solution was added. The beakers were sealed with a paraffin-latex film * and let stand at room temperature for the desired time. The plates were then removed and rinsed with distilled water, and the water was analyzed by the chromate method (*4*).

Finally, an experiment was performed in which successively decreasing areas were painted with the oil-base paint and dried for 7 days. These glass plates were immersed in successively increasing volumes of water. After an immersion period of 30 days the water was drained off and tested for dissolved lead by the more sensitive dithizone method (*5*). This procedure permitted an investigation of the range

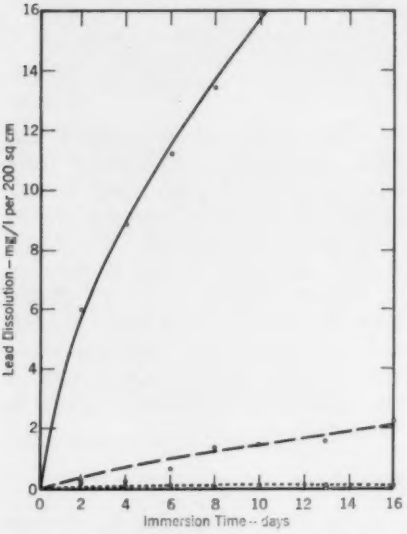

Fig. 1. Dissolution of Lead From Three Types of Paint Film

The solid, dashed, and dotted curves represent data for oil-, phenolic-, and vinyl-base paints, respectively. The oil-base paint had dried in air for 30 days. A decreasing rate of solution was evident.

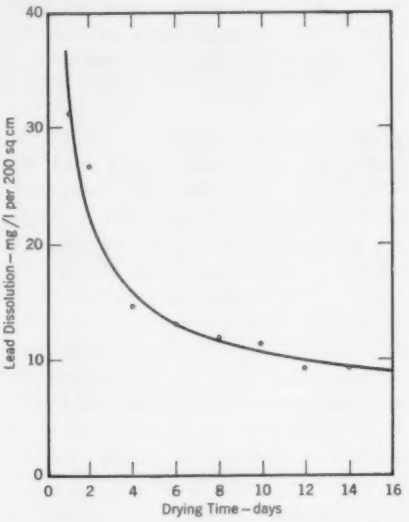

Fig. 2. Effect of Drying Time of Oil-Base Paint on Lead Dissolution

The extent of drying markedly affects the dissolution of lead; the dissolution rate appears to approach a constant value after 6 days.

* Sold under the trade name "Parafilm."

of area-volume ratios from the experimentally determined ratios to those that might be encountered in the field.

Immersion

The individual immersion experiments gave results shown graphically in Fig. 1. It is obvious from these results that the oil-base red-lead paint yields substantial and increasing amounts of lead with continued exposure (15.8 mg/l in 10 days) and, furthermore, yields more lead upon contact with water than either of the other two paints.

Drying

Painted glass plates were dried for the length of time (from 1 day to 2 weeks) indicated in Fig. 2. Each plate was then immersed for 3 days in distilled water, and the water was then analyzed for its lead content. It is apparent that the time of drying has an appreciable effect on the release of lead from the oil-base paint.

Repeated Immersion

As seen in Fig. 3, the results obtained with the oil-base paint show a decided decrease from the first high value of 16.50 mg/l until a nearly constant value of 2 mg/l was obtained after the tenth immersion during a total of 30 days.

Area-Volume Ratio

From Fig. 4 it can be seen that as the area-volume ratio (in square centimeters to cubic centimeters) decreases from 0.2 to 0.05 a straight-line relationship holds.

Residual Chlorine

The effect of residual chlorine upon red lead was studied. It was found with all three types of paint that within the normal range of 0.0–0.2 ppm residual chlorine, the lead solvency was increased during the period of the test. With higher residual-chlorine concentrations there was a further increase to a constant maximum, as shown in Fig. 5.

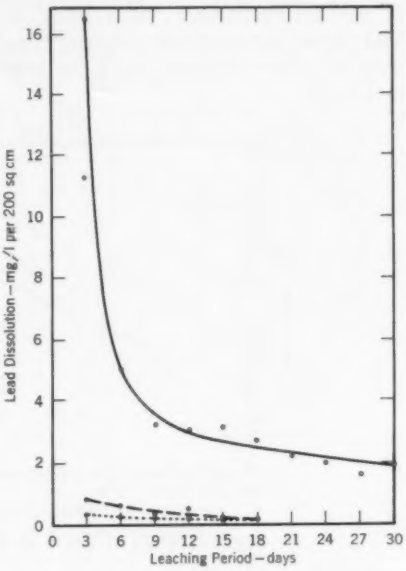

Fig. 3. Effect of Successive Leaching of Oil-Base Paint Film

Successive leaching with water resulted in a decrease in the amount of lead dissolved. The drying time for the paint film was 10 days.

Sodium Hexametaphosphate

The effect of sodium hexametaphosphate on the solubility of red lead was investigated. It was found that this salt caused an initial depression in solubility—an effect previously noted by Ruchhoft and Kashmar (*6*) with reference to other lead salts—and that

the solvent action was apparent only at relatively higher concentration values (25 ppm) for sodium hexametaphosphate (Fig. 6).

Sodium Hydroxide

The solvent effect of concentrations of sodium hydroxide up to 25 ppm was determined. With increasing amounts of sodium hydroxide the amount of lead carried into solution was decreased with all three types of paint, as seen in Fig. 7.

tration. It will be noted that in all three cases a pronounced solubility of the read lead occurs at pH 4.

Nature of Surface

Further studies were made of red-lead–painted plates of black iron, galvanized iron, and iron with a priming coat of zinc chromate conditioner. When the plates were completely covered with paint, the results obtained were similar to those obtained with glass plates. Results were somewhat

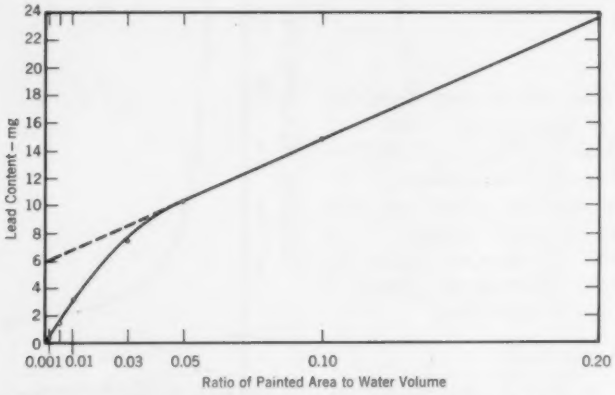

Fig. 4. Effect of Ratio of Water Volume to Contact Area

The amount of lead in solution plotted against the ratio of water volume to area of contact with the paint film gives a linear relationship for values greater than 0.05. When the ratio is reduced below 0.5, the amount of lead is less than would be expected.

Hydrogen-Ion Concentration

Variation in pH from 4.0 to 10.0 indicated a greater solvent effect on paint film by water on the acid side than that on the alkaline side of neutral water (Fig. 8). Sodium acetate buffer with either acetic acid or sodium hydroxide was used to cover the entire range and in as weak a solution as possible without losing the buffering capacity necessary to limit the effects of the acetate ion and to record only the effect of the hydrogen-ion concen-

lower where the red-lead paint blistered, formed pinholes, or became detached in any way so that the more basic metal was in contact with the solution. It was assumed that any such decrease was caused by the replacement of lead ions by the metal higher in the EMF series. Unpainted iron plates placed in the same beaker with glass plates with oil-base red-lead paint caused a reduction in values for the glass plates alone of 3.4 mg in a test period of 7 days.

Water From Different Localities

A series of glass plates painted with the various red-lead paints were immersed for 30 days in samples of water from eight localities in the United States. These localities were chosen to secure samples differing widely in fluorides, hardness, total solids, and pH value. The normal water analyses given in Table 2 are average analyses supplied by the water departments of the various cities and do not necessarily reflect the exact mineral content of the samples used. All water samples were tested for lead by the dithizone method before use and no lead was found by this method. After 30 days, water samples were analyzed for lead content by the chromate method (*4*). The effects of the various types of water tested on all types of paint were highly variable.

TABLE 2

Lead Solubility of Oil-, Phenolic-, and Vinyl-Base Paints in Various Waters, 30-Day Immersion

Locality	Lead Solubility *mg/l per 200 sq cm*			Water Analysis												
					Content—*ppm*											
	Base Oil	Base Phenolic	Base Vinyl	pH	Total solids	Na and K	HCO_3	SO_4	Cl	NO_3	Hardness as $CaCO_3$	Mg	Ca	Fe	SiO_2	F
Amarillo, Tex.	28.9	0.31	0.17	7.90	400	29	326	36	14	2.7	263	39	41	0.02	70	3.7
El Paso, Tex.	27.8	0.27	0.03	8.20	634	162	24	265	121	0.4	196	19	34	0.06	13	0.8
Jacksonville, Fla.	18.2	0.11	0.18	7.95	384	13	150	150	20	0.01	290	32	70	0.06	23	
Cleveland, Ohio	5.80	0.31	0.38	7.60	159	5.6	113	25	11		120	8.4	35	0.07		
Boston, Mass.	5.54	1.30	1.09	6.65	28	3.2	7	6	2.1	0.22	15	0.7	3	0.02	3.7	
Catskill, N.Y.	4.07	0.53	0.25	7.30	28	1.7	11	8	1.0	0.49	20	1.2	4.5	0.04	2.6	
Croton, N.Y.	3.62	0.60	0.15	7.45	69	2.9	41	11	2.6	0.88	51	4.2	12	0.05	9.6	
Seattle, Wash.	3.62	0.60	0.58	7.50	49	3.6	28	6	1.2	0.2	21	1.4	6.7	0.02	13	

TABLE 3

Lead Solubility of Red-Lead Paints in Various Prepared Waters

Paint Base	Lead Solubility—*mg/l per 200 sq cm*						
	Water Type						
	Distilled	pH 6	pH 7	pH 8	1 ppm Cl_2	5 ppm NaOH	5 ppm $(NaPO_3)_6$
Oil*	7.4	16.5	7.4	4.8	17.5	2.0	5.5
Phenolic	0.3	2.4	1.2	0.1	4.0	0.2	0.6
Vinyl	0.2	0.6	0.3	0.1	1.5	0.1	0.8

* After a 14-day drying period.

Discussion

Some of the pertinent data obtained in the study are summarized in Table 3, which shows clearly the increased rate of solution of lead during the test

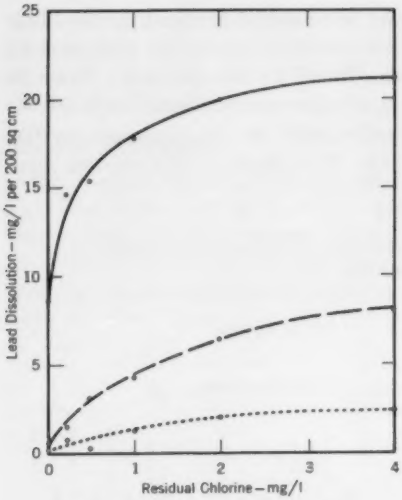

Fig. 5. Effect of Chlorine on Lead Dissolution

The solid, dashed, and dotted curves represent dissolution of lead from oil-, phenolic-, and vinyl-base paints, respectively. The oil-base paint had been dried for 94 days. Immersion time was 3 days.

period in the presence of residual chlorine or at low pH.

An outstanding point of interest revealed by this study is the *increased* amount of lead in solution following contact with red-lead oil-base paint in comparison with the amount resulting from red-lead powder suspended in water. The theory, therefore, that a protective film retards the solution of red lead is not tenable in this situation.

An explanation for this was found in the effect of linseed oil on red lead. Reaction between these two results in the formation of either a small amount of lead soap, presumably lead lineolate, or a glyceride of lead (*7–9*). A preparation of the lead salt of the fatty acids of linseed oil was found to exhibit similar solution properties and higher values than those of the oil-base film itself. Although no figures for lead lineolate are available in the literature, calculated values for lead palmitate, lead myristate, lead stearate, and lead laurate (*10*) vary from 21.2 mg/l to 46 mg/l. The value for the solubility in water of lead lineolate prepared from linseed oil used in the paint experiments in this investigation was found to be 41.1 mg/l. It is understandable, therefore, that appreciable amounts of the lead salt would leach out of this type of paint film in contact with water. The effect of repeated leaching should furnish a clue as to whether or not this is merely a surface effect, which yields a relatively high initial concentration of lead and tends to wash off and de-

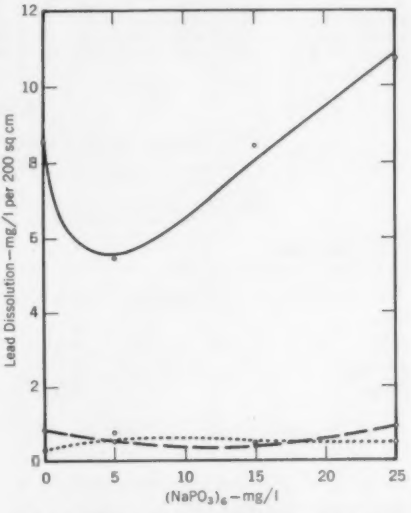

Fig. 6. Effect of Sodium Hexametaphosphate on Lead Dissolution

The solid, dashed, and dotted curves represent oil-, phenolic-, and vinyl-base paints, respectively. Drying time for the oil-base paint was 97 days.

crease in amount. The results obtained with the three types of paint exhibit such an effect. The uptake of lead after 30 days of successive immersion, however, approaches a nearly constant value of 2 mg/l per 200 sq cm of surface that is painted with the oil-base paint.

Figure 9 shows how the area-volume ratio changes with the water level in two cylindrical tanks whose heights are equal to their diameters. Comparison with Fig. 4 indicates that the values of lead concentration to be expected in public water supply tanks during normal operation would be less than those determined experimentally using an area-volume ratio of 0.2.

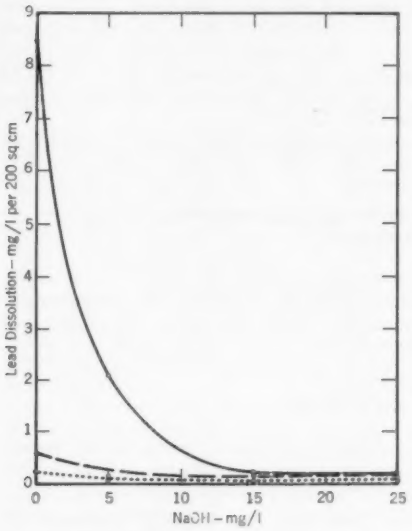

Fig. 7. Effect of Sodium Hydroxide on Lead Dissolution

The solid, dashed, and dotted curves represent lead dissolution from oil-, phenolic-, and vinyl-base paints, respectively. The drying time for the oil-base paint was 97 days. Immersion time was 3 days.

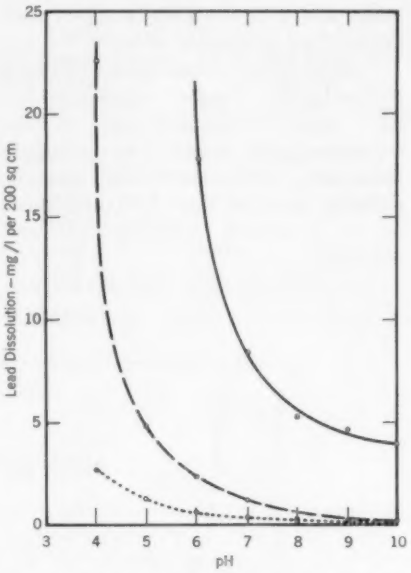

Fig. 8. Effect of pH on Lead Dissolution

The solid, dashed, and dotted curves represent oil-, phenolic-, and vinyl-base paints, respectively. An increase in hydrogen-ion concentration markedly increased the amount of lead carried into solution. The drying time for the oil-base paint was 15 days. Immersion time was 3 days.

Summary

In this laboratory study the effects of a number of variables on lead solubility were studied separately for three types of paint.

The uptake of lead by water standing in contact with oil-base red-lead paint varies with the time of contact.

The amount of lead dissolved by water in contact with oil-base red-lead paint varies inversely with the time of drying of the paint film.

Repeated immersion tests indicated that the leaching is partly a surface

effect and that the dissolution of lead approaches a constant value.

Sodium hexametaphosphate causes a reduced rate of lead dissolution in distilled water within the range of concentration used in public water supply treatment. At relatively high concentrations (greater than 15 ppm) there is an increased solubility of lead observed.

Sodium hydroxide in concentrations of up to 25 ppm depressed the rate of solution of lead with all three types of paint.

An increased hydrogen-ion concentration up to pH 4 caused a pronounced increase in the rate at which lead was dissolved from the oil-base paint as well as the phenolic-base and vinyl-base paints.

The nature of the material painted did not affect the lead solubility provided that no free metal was in contact with the water.

The character of the waters found in different localities had a profound effect on the rate of solution of red lead from paint films.

Of the three paints tested, the oil-base paint was found to be at least ten times more soluble under the conditions of the test than either the phenolic- or vinyl-base paint. It is to be noted that the oil-base paint used did not contain the added litharge found in current specifications.

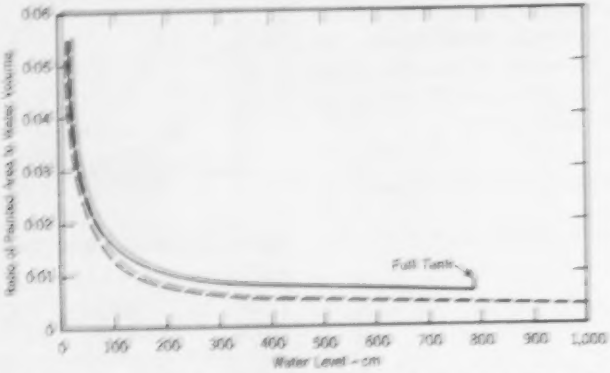

Fig. 9. Relationship Between the Area-Volume Ratio and Water Level in Storage Tanks

The curves represent the change in the area-volume ratio as the water level is increased in two cylindrical tanks of different dimensions. Solid curve: 100,000-gal tank; radius 392 cm; height 784 cm. Dashed curve: 750,000-gal tank; radius 763 cm; height 1,052 cm.

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Lead Content of Water From Tanks Painted With Red Lead

Hervey B. Elkins

A contribution to the Journal by Hervey B. Elkins, Director, State Div. of Occupational Hygiene, Boston, Mass.

FOR many years standpipes and tanks for water storage have been painted on the inside with red-lead paints. This fact is not surprising, because in the past lead paints have been generally superior to paints containing other pigments.

The presence of lead in drinking water in sufficient amounts to cause intoxication has been noted occasionally. So far as the author has been able to determine, the source of the lead has nearly always been lead pipe, usually in domestic plumbing. Furthermore, even lead pipe, as a rule, presents a serious problem only if the water is soft and acidic.

During World War II, the question of the suitability of red-lead paints in tanks used for potable water was raised. Laboratory studies undertaken by the USPHS indicated that some lead was dissolved from panels coated with red-lead paints. As a result of this finding, it was suggested that the use of lead paint be prohibited in tanks and standpipes used for the storage of potable water.

Nature of Study

At the request of the Lead Industries Association, a study was made of the lead content of water from several standpipes which had been painted internally with lead paint. This study, which was begun in 1950, has involved analysis of 70 samples of water from eleven different standpipes coated with three different types of paint:

1. Red lead in linseed oil (Federal Specification TT-P-86a, Type I), which is the paint which in the past has been mainly used in water storage tanks

2. Red lead in a phenolic vehicle (Federal Specification TT-P-86a, Type IV), which is currently the preferred paint in many quarters, being faster drying and supposedly more durable than Type I

3. Lead chromate in a phenolic vehicle, referred to as chromate paint (pigment analysis: basic lead chromate, 33–38 per cent; zinc chromate, 13–18 per cent; hydrated ferric oxide, 10–15 per cent; inert pigment, 35–40 per cent). This paint has been widely used in New England.

Samples were taken from four standpipes immediately after painting. At three of these tanks, samples were taken at intervals for virtually the entire life of the paint, 5, 8, and 8 years, respectively. The largest number of samples was taken from tanks painted with Type IV paint, as Table 1 shows, because the main interest, especially at the beginning of the study, was in Type IV paint.

Three of the tanks coated with Type IV paint were in New Jersey. The remaining eight were in Massachusetts.

They varied in size from 75,000 gal to 3.7 mil gal. Samples were collected by engineers of the Massachusetts Department of Public Health, by water utility personnel, and by the author. Most samples were drawn off from outlets adjacent to the standpipe, a few were dip samples, and some were from outlets somewhat removed from the tanks.

Analysis

Because it was desirable to detect very small traces of lead, large samples (400–500 ml) were analyzed. The lead was concentrated by coprecipitation with calcium oxalate. This was found preferable to evaporation or direct extraction with dithizone. The determination was made with a dithizone colorimetric procedure. Analysis of knowns indicated complete recovery and an accuracy of ± 10 per cent if the lead content exceeded 0.02 mg/l.

TABLE 1

Summary of Tests on Lead Dissolution in Red-Lead–Painted Tanks

Paint	No. of Tanks	No. of Samples
Type I	4	5
Type IV	5	51
Chromate	2	14
None*		20

* Tank influent before contact with paint.

Results

The results of the 90 analyses are summarized in Table 2. The only samples with a lead content above the permissible limit of 0.1 mg/l were three from tanks in standby service. One had just been painted with chromate paint, and the other had been painted about 3 years earlier with Type I paint.

The next highest lead concentration was 0.05 mg/l, from a standpipe painted with Type IV paint about 1 year previously. Another sample from the same tank taken at the same time had a negligible lead content. The water from the tanks in active service (65 samples) had an average lead content of 0.006 mg/l. This is only 0.003 mg/l above the average of the influent samples. According to these results, the lead added to the water by the paint in the tank is only 3 per cent of the permissible limit of 0.1 mg/l.

It may be asked how these results can be reconciled with the findings of Fairhall and Fraser of USPHS—namely, that lead dissolves freely from lead paints such as those used in these standpipes. The obvious explanation is that the water does not stay in the tank long enough to pick up appreciable amounts of lead. The three standpipes studied most thoroughly were in institutions where the daily water consumption approximated the tank capacity.

A few panel studies carried out in the author's laboratory in general confirm the report of USPHS that appreciable amounts of lead are dissolved, especially from Type I paint. As a

TABLE 2

Results of Analysis of Water Samples From Red-Lead–Painted Tanks and Standpipes

Lead Content *mg/l*	No. of Samples	
	Standpipe	Influent
0.000–0.005	50	13
0.006–0.010	7	4
0.011–0.020	8	1
0.021–0.050	2	2
0.051–0.100	0	0
0.11–0.50	3	0

matter of fact, Type I paint with litharge added, which, the author understands, is frequently used, gave off appreciably more lead during the first few months than straight red lead in oil. The results of these tests are summarized in Table 3.

It can be seen that, even with oil-base paints, a daily consumption of less than the capacity of the standpipe results in a lead content from the paint of less than 10 per cent of the maximum allowable level. With Type IV paint, a much lower consumption will yield the same results. With larger tanks, a lower turnover is needed to effect an equal dilution of the lead, because the area of the tank walls and bottom is less, in comparison with the volume, than in the smaller tanks. Conversely, with smaller standpipes a higher rate of water turnover would be needed.

TABLE 3

Lead Dissolution From Red-Lead–Painted Tanks

Paint	Avg Lead Dissolution—*mg/sq ft/day*	
	First 2 wk	First 3–9 mo
Type I and PbO	5.5	0.90
Type I	2.2	0.56
Type IV	0.31	0.10

The author does not believe that any of those who object to the use of red-lead paint in standpipes seriously thinks that enough contamination of the drinking water can result to produce a significant number of cases of lead intoxication. The permissible limit of 0.1 mg/l provides a substantial margin of safety for the average person, as it should. According to the findings reported here, this level was not even approached in most of the samples, nor would it be in most systems.

It has been proposed, however, that even although harmful levels of lead are not produced in the drinking water, any increase in lead consumption is undesirable and should be prevented. The author can agree with this argument to a certain extent. If all the water consumed by a large population contained lead right up to the permissible level, a careful statistical study might reveal marginal harmful effects to a small number of individuals with occupational or other exposures to lead, as the amount of additional lead intake required to produce intoxication would be somewhat reduced. As the lead content of the water is lowered substantially below 0.1 mg/l, however, this possibility becomes very small. It is doubtful that any effect at all could be detected by the most refined method in a population whose water supply contained 0.01 mg/l of lead, in comparison with one whose water was absolutely free of lead.

TABLE 4

Turnover of Water and Calculated Lead Dissolution

Paint	Time After Painting *wk*	Lead Content *mg/l*	Turnover *gpd*
Type I and PbO	2	0.1	31,000
	36	0.01	51,000
Type I	2	0.1	12,000
	36	0.01	32,000
Type IV	2	0.1	1,800
	14	0.01	5,700

If one assumes the same ratio of solution of lead from the interior of a

given standpipe as was found in the panel experiment, one can compute the rate of water turnover needed to keep the lead content within specified limits. Such calculations for a standpipe 26 ft in diameter and 20 ft high are shown in Table 4. This is a small standpipe (about 100,000 gal), and represents rather an unfavorable ratio of surface to volume.

Other Sources of Lead in Water

There are other much more important sources of lead intake than lead paint in water standpipes. One such source is domestic plumbing. By this is not meant lead pipe, but modern plumbing with iron, brass, and bronze pipe and fittings.

The author and one of his colleagues recently analyzed samples of water in their office and in their homes, taking samples from the faucets and water coolers the first thing in the morning and later after the water had run for some time. The results are given in Table 5. In each set of samples the lead content of the water in the first sample was measurably greater than that of the second, and in two cases the difference was significant. These quantities of lead are insufficient to cause any concern, and anyone who advocated new plumbing in a house because of lead concentrations of this order would indeed be considered an extremist. Furthermore, according to the findings reported in this article, the lead hazard from paint in water tanks is even less.

Possible Exceptions

These studies were, of course, limited to a relatively small number of tanks, all in the same section of the country. Although some unfavorable conditions, notably the softness and acidity of the waters, which were mostly in the pH range 6.0–6.6, favored the extraction of lead, other factors, such as higher temperatures and chlorine content, may be more prevalent in other areas. In the author's opinion, however, the most important factor is the rate of turnover of water in the tank.

It is within the realm of possibility, in isolated instances, that the water consumed by a given population may be stored in a standpipe for several days. In such situations, which, if they occur at all, almost certainly involve relatively small numbers of people, it might be that some coating other than Type I paint would be advisable for the interior surface. It is exceedingly hard to imagine a water supply system, with a tank of comparable capacity to that of the tanks studied, in which storage could be so prolonged that Type IV paint would be unsuitable, according to the results of the author's test.

TABLE 5

Lead in Water From Plumbing

Source	Lead Content—*mg/l*	
	Morning Sample	Later Sample
Office	0.034	0.002
Home A	0.024	0.010
Home B	0.007	0.004

Conclusion

A study of the lead content of water from eleven standpipes painted with lead paint has been made. Of 70 samples of water, only three contained significant amounts of lead, and these were from tanks in standby service. Tests of the extraction of lead from

panels coated with red-lead oil paint indicate that no significant quantity of lead is added to the average water supply by the paint if the average daily consumption approaches the capacity of the tank; and if a phenolic base paint with a red-lead pigment is used, a substantially lower rate of turnover is essential to keep the lead concentration below significant levels.

All the evidence available indicates that only under extremely exceptional conditions, if at all, could the use of lead paint in standpipes for potable water be considered inadvisable from the standpoint of the public health.

Coagulant Aids for Potable-Water Treatment

The USPHS Technical Advisory Committee on Coagulant Aids for Water has added the following products to the list of those which may be used for water treatment—in the concentration recommended by the manufacturer—with no adverse physiological effects on water consumers: Hagan Coagulant Aids No. 801 and No. 952, manufactured by Hagan Chemicals and Controls, Inc., Nalcolyte No. 110, manufactured by National Aluminate Corporation; Permutit No. 68, manufactured by the Permutit Co.; and Ecco Suspension Catalyzer No. 146, manufactured by the Electric Chemical Co.

The committee's findings bear only on the health aspects of the use of such products and do not constitute an endorsement or indicate their effectiveness in the proposed use. The names of other coagulant aids on the committee's list were published in the February 1959 issue of the JOURNAL (p. 233).

Water Supply Protection Activities of the US Public Health Service

Gordon E. McCallum

A paper presented on Oct. 16, 1958, at the Iowa Section Meeting, Des Moines, Iowa, by Gordon E. McCallum, Chief, Water Supply & Water Pollution Control Program, USPHS, Washington, D.C.

UNTIL recently the major interest in the water field was usually large construction projects for hydroelectric power, reclamation, or irrigation. Now a transition is taking place and municipal and industrial water supplies are becoming major factors in water resource development. As needs increase and sources close to population centers are fully developed, water supply projects will have to be extended farther and farther. The quest for new sources of potable water undoubtedly will become more serious.

The USPHS has had an interest in water supply since about 1900. The role of USPHS, as in many of its other programs, has been to work with other federal agencies and to assist the states and local communities in handling technical problems. Much of this work has been in the areas of research and investigation.

It is sometimes difficult to distinguish between water supply and water pollution control activities of USPHS. The general program objective in controlling pollution is to keep water fit for legitimate uses, and municipal water supply is the most important of these uses. Consequently, this article will be limited to USPHS activities which have a direct bearing on the water supply field.

Basic Data

Basic data on water resources have been compared to similar data in the field of public health. The main difference is that public health officials have far more information available. The necessity for facts on the quality of the nation's water is, however, becoming widely recognized and this in itself is an encouraging development. In view of the past expenditures to control pollution it is strange that there has not been more interest in what has been happening to many surface water supplies, whether they are deteriorating or improving, and what the long-term trends are. Lack of information on water quality has been a matter of concern to various water resource study commissions and committees established by the federal government. This concern was expressed forcefully at the hearings on federal water pollution control legislation in March 1956. As a result, Congress added to this legislation a specific authorization directing the surgeon general, in cooperation with federal and state agencies, to collect and disseminate basic data on chemical, physical, and biological quality of water.

A major objective of this program is the ultimate establishment of a national network of water quality sam-

pling stations on interstate streams. At the present time (October 1958) 50 of these stations have been established by USPHS. States and local governments also are establishing such stations on bodies of water which are of particular importance in their immediate areas.

Locations of sampling stations are bodies of water in one or more of three categories: [1] major waterways used for public water supply, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, or other uses; [2] interstate coastal and boundary waters; and [3] waters which may be affected by activities of the federal government.

A program of this type will ultimately provide a continuous record of water quality throughout the nation and should give water supply authorities the necessary reliable data on water quality. The principal objectives of the program are to furnish: continuous information on the nature and extent of pollution affecting water quality; long-term information on changes in water quality resulting from changes in water use and development; data which will guide state, interstate, and other agencies in their pollution control programs; data on water quality which will be useful in the development of a comprehensive water resources program; and data useful in the selection of sites for municipal and industrial water use, and for other purposes.

The kinds of basic water quality data to be supplied were agreed upon by consultation between USPHS and the various cooperating agencies. Those considered to be of most value at that time and which are presently being studied are: radioactivity; plankton organisms; coliform organisms; organic chemicals; and most of the standard physical, chemical, and biochemical measurements of polluted water. The examinations for radioactivity, plankton, organic chemicals, and coliform organisms are made at the USPHS Robert A. Taft Sanitary Engineering Center (SEC), Cincinnati, Ohio. State and local laboratories make most of the standard water quality determinations. A majority of these cooperating laboratories in the interstate sampling program are maintained by municipal water utilities.

Radioactivity and Chemical Measurement

Surface waters contain some radioactivity from natural sources. The increasing development of nuclear energy, however, has caused radioactive material in waters to increase. The measurement and recording of background radiation levels before the use of nuclear energy greatly increases is extremely important. As the use of nuclear energy increases continuous surveillance of these radiation levels for protection of the public health will be necessary.

Radioactivity measurements are made on all samples from the USPHS 50-station interstate network. Although these data are supplemented by reports from several hundred observers in many parts of the United States, the number of stations measuring radioactivity needs to be increased.

Gross alpha and beta measurements are made on both suspended materials and dissolved solids in raw surface water. The total radioactivity detected indicates gross contamination. Radioactive levels of dissolved solids provide an approximate measure of the levels which may be found in treated water from which most of the suspended matter has been removed. Alpha levels

generally reflect variable contamination due to fallout, nuclear energy installations, and use of radioactive isotopes in laboratories.

The mining and milling of uranium ores is presenting a growing problem in radioactive pollution. A number of field studies have been made by USPHS in Colorado, New Mexico, and Utah at the request of state health departments. These and other studies are assisting in the preparation of a "waste guide" for the uranium milling and refining industry. At the request of the New Mexico Department of Health a conference was held in April 1958 on interstate pollution of the Animas River by uranium wastes. The conference resulted in an agreement to undertake a fact-finding survey and institute such corrective measures as might be indicated by this survey.

The USPHS sampling network has not been in operation long enough, nor is it yet large enough, to report meaningful trends in radioactivity levels.

The nation's waters are receiving increasing amounts of organic chemicals, most of which come from domestic and industrial wastes. Lesser amounts, but still of real concern because of their toxic properties, come from the increasing use of agricultural chemicals and "economic poisons," such as insecticides, herbicides, and rodenticides. Millions of pounds of these organic chemicals are already produced annually and this total is expected to increase. Consequently, it is desirable to watch closely the extent to which these substances reach and affect water courses.

Little is known about the pollutional behavior of these organic chemicals, and even less is known about ways of preventing their escape into streams. Most of these chemicals pass through conventional water and waste treatment processes without being changed. Some of them actually interfere with these processes. They cause serious taste and odor problems and taint the flesh of fish, and some of them are highly toxic to fish and other aquatic life. This may explain why it is the conservationists rather than health or water officials who are taking the lead in demanding that more attention be given to this problem.

The carbon filter technique is a useful tool in the measurement of organic pollution. It is being used more and more in the study of tastes and odors in both surface and ground water. In one instance a municipal water supply was thought to be polluted by petroleum refinery wastes. The company suspected of being the source of the pollution questioned whether its operations were responsible. By use of the carbon filter the cause and source of the tastes and odors were conclusively demonstrated. As a result, changes were made by the company to eliminate the pollution. Successful application of the carbon filter by municipalities has also been demonstrated by a group of water plants on the lower Missouri River in using it to trace the causes of taste and odors.

The USPHS program is receiving an increasing number of requests involving use of the carbon filter in the study of ground water contamination. This is especially true in cases where the suspected pollutant is a petroleum product. Positive identification and source of pollution in well water has been determined in a number of recent cases. Studies to improve the carbon filter technique and its application are continuing.

Research Projects

Water supply study constitutes a substantial portion of the research program at the SEC. Some of the projects on which progress has been made are:

1. *Studies of algae.* A manual on algae in water supplies (*1*)—to be published soon—contains keys and descriptions of the organisms and gives information on the various problems caused by the different types.

2. *Qualitative and quantitative plankton studies.* Better methods of analyzing water samples for plankton content are constantly being sought. A new plankton-counting cell has been developed which makes possible greater accuracy in counting and differentiating the smaller organisms.

3. *Studies of infestations in distribution systems and treatment plants.* An increasing number of reports of nematodes, copepods, algae, and slime-forming organisms in distribution systems stimulated a study for better methods of control. It is well known that diatoms and other aquatic organisms affect the efficiency of water treatment processes. A study of nematodes in sand filters has resulted in special procedures for detection and enumeration of filter-clogging algae. A special study of treatment plants in the Great Lakes area is now under way.

4. *Virus studies.* Recent work has shown that viruses exhibit considerable variation in their reaction to water treatment processes. The efficiencies of alum and ferric chloride in removing Coxsackie and bacterial viruses from water by flocculation have recently been evaluated. The removal pattern with increased alum dosage is very similar for the two types of virus. The bacterial virus is more readily removed than the Coxsackie, however. Substantially more free chlorine is required to kill Coxsackie than to destroy *Esch. coli* or *Salmonella typhosa.* There appears to be a high degree of correlation between Coxsackie virus survival time in natural waters and the degree of pollution of such waters.

5. *Membrane filter studies.* Extensive field tests to determine the reliability of the delayed incubation membrane filter technique indicate that this procedure is a reliable and suitable method for determining coliform concentrations.

6. *Other studies.* Studies are also under way on: the role of actinomycetes in taste and odor production; efficiency of silver disinfection; pseudomonas and enterococcus as indicators of fecal pollution; fundamentals of sand filters; removal of organic chemicals from water; treatment of farm ponds for small water supplies; reservoir evaporation; and ground water pollution.

Other Activities

USPHS has been collecting and disseminating water supply inventory data since 1910. Considerable progress has been made recently and now, for the first time in 10 years, a comprehensive inventory of water supply facilities in the United States will be made available. An inventory of facilities of communities with a population of 25,000 or more has been revised and is to be published in 1959 (*2*). A similar inventory for communities with less than 25,000 population is in preparation and is scheduled for publication in 1959 (*3*).

Some of the items added to the new inventories are: safe yield; transmis-

sion capacity; maximum, minimum, and average plant output; overload capacity; and improvements needed.

Inventory data—machine-tabulated for quick use—are widely used by federal and state agencies, the armed forces and civil defense authorities, municipal officials, researchers in universities and other establishments, equipment manufacturers, and consulting engineers. As a result of the machine method of tabulating inventories data on any specific river basin can be included in one inventory. It is felt that availability of this information is vital to both local and regional water supply planners.

The Director of the Office of Civil and Defense Mobilization, former Governor Leo A. Hoegh of Iowa, has shown a marked interest in water supply. The work of USPHS in civil defense includes the assessment of damage to water utilities. Data on water utilities in selected cities are adapted to computer techniques for assessing damage. This is done in cooperation with the National Damage Assessment Center of the Office of Civil Defense and Defense Mobilization. At first this activity was concerned with the extent of possible water supply damage due to enemy attack in the selected cities and it now includes water which might be undamaged in other cities.

This activity is part of the National Damage Assessment System, the purpose of which is to make possible early postattack decisions without awaiting field reports on actual damage. Data being collected are expected to allow calculation of probable damage to water supplies and to provide a basis for national planning following an attack. They should, for example, provide a basis for planning relocation of government, population, and industry, as well as an assessment of the need for critical water personnel and equipment.

USPHS drinking water standards (*4*) were last revised in 1946. New types of contaminants in water now require new techniques for measuring and removing them. Consequently, the standards are being revised in the light of changing conditions.

The USPHS manual of recommended water sanitation practice (*5*) will be brought up to date concurrently with revision of the standards.

At the request of AWWA and other groups USPHS is investigating whether the many recently developed coagulant aids are safe to use. In 1957, the surgeon general established an advisory committee on coagulant aids, which included among its members experts in the fields of toxicology, chemistry, and water supply engineering. The committee appraises the production, composition, and toxicity of materials proposed for use in drinking water. When the committee is assured that materials are safe for use it advises USPHS, which notifies the states and the water utilities.

USPHS will continue to furnish technical assistance in the form of research, publications, consultation, and training. Many are familiar with the advanced water supply training courses at the SEC, which are given expressly for water utility personnel.

Although it is not a USPHS program, one new aspect of water supply planning is the Water Supply Act of 1958 which authorizes the US Corps of Engineers and the US Bureau of Reclamation to provide municipal and industrial water storage in multipur-

pose reservoirs. This legislation is of the utmost significance and will have a profound effect on the future growth of many communities now that sources of supply are becoming of increasing concern. Briefly, this act permits a maximum of 30 per cent of the estimated cost of a project to be charged to water supply needs. All costs allocated to water supply are to be repaid within 50 years after the project is first used for that purpose. Payments need not be made, however, until the water is first used; interest is charged to the prospective user after a period of 10 years. USPHS has been asked by the Department of the Army and the Department of Health, Education, and Welfare to collaborate in the administration of this important program.

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Legal Aspects of Municipal Water Supply in the Pacific Northwest

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A paper presented on May 15, 1958, at the Pacific Northwest Section Meeting, Spokane, Wash., by Ernest H. Campbell, Assoc. Director, Bureau of Governmental Research & Services, Univ. of Washington, Seattle, Wash.

THE primary emphasis in these remarks will be on accumulated legal experience in Washington, but the observations made will be applicable to a substantial degree to other governmental areas and jurisdictions. The states and other units of government represented in the Pacific Northwest Section of AWWA all have statutes or rules and regulations designed to protect the public against the purchase or drinking of contaminated water and to assure the quality of that water. Although this article indicates some legal guidelines, administrators of water systems should, when confronted with specific legal problems, promptly secure competent legal advice.

Proprietary and Governmental Functions

Until recently, by reason of the recognized legal distinction between proprietary and governmental functions, a municipal corporation has generally been considered to have a dual character. In its first aspect, it is governmental, public, or legislative; in its second, it is corporate, private, or proprietary.

Many reasons have been given by various courts for granting immunity from tort liability to a municipal corporation when it acts in a governmental capacity. Among these are those listed below.

1. The state is sovereign, and the municipality is its governmental agency; the state may not be sued without its consent, and its agent therefore cannot be

2. The municipality derives no pecuniary benefit from the exercise of public functions

3. Members of municipal departments in the exercise of public governmental duties are agents of the state and not of the city; hence the doctrine of *respondeat superior* has no application

4. It is necessary for the proper performance of governmental functions that a municipal corporation should not be liable for the negligence of its agents

5. Municipalities should not be liable for torts committed in the performance of duties imposed by the legislature, but only for those voluntarily assumed under general statutes

6. Taxes raised for specific governmental purposes should not be permitted to be diverted for payment of damage claims (*1*).

It is possible that a recent decision of the Florida Supreme Court (*2*) may reflect a change in the general climate of judicial thinking with respect to the distinction between pro-

prietary and governmental functions. An action for damages was brought against a municipality by the surviving wife for the alleged wrongful death of her husband, who, through the negligence of a city jailer, died of smoke suffocation while left unattended and unprotected against fire after having been incarcerated in a helpless, intoxicated condition. The circuit court sustained the city's motion to dismiss, and the wife appealed. Upon appeal, the supreme court reversed the decision of the lower court and held that, under the doctrine of *respondeat superior,* an action could be maintained against the city for an alleged wrongful death occasioned by the negligence of a police officer acting within the scope of his authority or employment.

Traditionally, tortious acts of police officers who are acting within the scope of their employment do not render the municipality liable for the death or injury of private persons, as police functions are generally considered to be governmental and not proprietary. The same rule has been applied to officers in charge of municipal prisons. When, however, the function is a proprietary function, the city is subject to the same liability as private persons. This decision severely limited the common-law rule that municipalities are immune from tort liability while performing governmental functions; the court indicated that tort liability would be imposed on municipal corporations for all tortious acts of their agents committed within the scope of employment, except for acts committed in the performance of legislative, judicial, quasi-legislative, or quasi-judicial functions.

This decision has attracted a great deal of attention and many are wondering to what extent other courts now will follow the precedent it established. In recent years the distinction between governmental and proprietary functions has been subject to a great deal of criticism, and the trend has been to construe more and more governmental functions as proprietary and thus to narrow the area of municipal immunity from tort liability.

The Florida Supreme Court stated:

> The time has arrived to face this matter squarely in the interest of justice and to place the responsibility for wrongs where it should be.
>
> We, therefore, feel that the time has arrived to declare this doctrine (immunity from tort liability with respect to governmental functions) anachronistic not only to our system of justice but to our traditional concepts of democratic government.

The court stated that it was convinced that the new rule established by this "would be productive of results more nearly consonant with the demands of justice" (*3–5*).

Liability

Although there is some judicial authority to the contrary (*6*), the Supreme Court of Washington is firmly committed to the view that when a municipality maintains, operates, or constructs a water utility to sell water for private consumption, it acts in a proprietary, or corporate, capacity as distinguished from a governmental capacity. A municipal corporation operating a water utility is therefore subject to the same rules governing liability as any private owner of a water utility. With a few exceptions, such as establishing or permitting a nuisance, while municipal corporations are engaged in the performance of such governmental functions as fire and police functions, they may not be held

liable for the negligence of their officers and employees (*1*).

The underlying test in distinguishing governmental functions from proprietary functions in Washington, and consequently of determining the liability or nonliability of the municipality for torts of its officers and agents, is whether the act is performed for the good of the public generally or whether it is for the special benefit or profit of the municipality as a corporate body.

Care must be exercised to safeguard against the potential liability to which a city is subject in the operation of a water system. It is essential that the personnel who make repairs on a municipal water system are adequately trained, particularly if such repairs are done by force account.

Municipal Water Sanitation

Because water may be a carrier of many diseases, it is imperative that a public water utility be so administered as to assure an adequate supply of safe, potable water. The epidemic of typhoid fever in 1923 in the city of Everett, Wash., which resulted from contaminated water, pointed up the need for insuring that wholesome water is supplied for domestic purposes (*7*). Substantial judgments were obtained against the city of Everett because deaths resulted from the drinking of polluted water. The pollution was caused by water that flowed, by means of an open gate valve in a bypass, through the mains of a mill company's plant from the Snohomish River, through the bypass, and into the city water mains. The litigation arising out of this typhoid epidemic serves as a warning that:

1. When a water main is laid to connect two laterals so that the existing bypass is no longer needed, the latter should be removed by the city.

2. It is not sufficient that a user be advised that such a bypass is dangerous and that the user promise to remove it; the promise of the user to remove a bypass connecting the city water supply with its polluted supply does not relieve the city of liability for negligently allowing the bypass to remain. In the case cited above, the city was negligent because it waited for almost 2½ months after the new connection was made to determine whether the gate valve was closed or if the bypass had been removed as the mill company had promised.

3. When a city receives complaints about the appearance of water and reports that people are becoming sick because domestic water is polluted, the failure of a city to take prompt steps to ascertain whether or not the water is polluted may be considered negligence.

4. Failure to check water quality properly to insure that it is free from contamination is negligence.

Some time ago a city received a number of complaints about its domestic water supply. The city officials promptly commenced an investigation and found a dead deer in the river from which the city received its water supply; action was taken at once to remedy the condition.

Rules of Board of Health

The regulations of the Washington State Board of Health relating to sanitation and public water supplies (*8*) define a cross connection as "any physical arrangement whereby a public or semipublic water supply system is connected, directly or indirectly, with any other water supply system, sewer, drain, conduit, pool, storage reservoir, plumbing fixture, or other device which

contains, or may contain, contaminated water, sewage, or other waste or liquid which would be capable of imparting contamination to the public or semi-public supply as a result of backflow." It defines a bypass as "a physical arrangement whereby water may be diverted around any feature of the purification process of a public water supply." All cross connections, as defined in these rules and regulations, are prohibited, "whether or not such cross-connections are controlled by automatic devices, such as checkvalves, or by hand-operated mechanisms such as gate valves or stopcocks." Under these rules and regulations, failure on the part of persons, firms, or corporations to discontinue the use of all cross connections and to separate physically any cross connection is sufficient cause for the discontinuation of water service to the premises on which the cross connection exists. Bypasses whereby water may be diverted around any feature of a purification process of a public water supply system are prohibited by these rules and regulations, except that, with the specific approval of the State Board of Health, bypasses may be permitted around primary sedimentation basins, aerators, or mixing chambers. These rules and regulations also authorize water supplies, not approved for drinking and culinary purposes by the State Board of Health, to be made available for fire protection by four methods only:

1. Construction of a pump sump or reservoir into which the city mains discharge with a free fall, equal to not less than two diameters of the discharge pipe above the maximum spill line of the pump sump or reservoir, with pumps serving the independent system by taking suction from the pump sump or reservoir and pumping directly into the fire protection system; or

2. An elevated tank or standpipe supplied at the top by a discharge from the city main with a free fall, equal to not less than two diameters of the discharge pipe above the maximum spill line of the elevated tank or standpipe. Such tank or standpipe may then be connected to the fire protection system; or

3. Installation of a "swing-connection" designed and operated in such a manner that when the private source is serving the independent system, the public supply is completely severed, and when the public source is serving the independent system, the private supply is completely severed; or

4. Two independent systems of piping without any connection, whatsoever, one being supplied from the public system and the other from the independent water supply.

A number of home owners in various parts of Washington have installed so-called T-pipes, cross connections to provide an auxiliary source of supply from wells or streams, thereby introducing a possible source of pollution of the city water supply or that of a private company. By virtue of the regulations of the State Board of Health, a city could require the user to take such action as it deems necessary, even to eliminate the T–cross connection, to safeguard against possible pollution of the company's water, as it is a violation of the rules and regulations of the State Board of Health to affect adversely the other users of the water system. The local health officer has a measure of responsibility in locating and eliminating any cross connection that could result in pollution.

A city, by ordinance, could reserve a continuing right to inspect the water supply line on the premises of the user and provide in the ordinance that no cross connection may be made with the municipal water system. Water

users could be permitted to obtain an auxiliary supply of water by the installation of a separate pipe having no interconnection with a city or privately owned system and connected to a separate supply tank.

Fluoridation

The rules and regulations of the board of health of the state of Washington also contain a section which prescribes the terms and conditions under which fluoridation of the public water supply may be provided for.

In 1954, the Supreme Court of Washington was called upon to determine whether fluoridation of water constituted an invasion of the constitutional rights of the individual. In a five-to-four decision, in *Kaul* v. *City of Chehalis et al.* (*9*), to enjoin the defendant city from fluoridating the city water supply pursuant to an ordinance authorizing such action, the court held that fluoridating the city water supply did not invade any constitutional right of the plaintiff. The court indicated that liberty implies the absence of arbitrary restraint; it does not necessarily imply immunity from reasonable regulations imposed in the interest of the community. The court observed:

> There is a direct and significant relationship between dental health and general bodily health of individuals. We find nothing in this jurisdiction which limits the police power, exercised in the realm of public health, solely to the control of contagious diseases, as distinguished from noncontagious diseases.

Four judges dissented on the ground that the ordinance providing for fluoridation is unconstitutional because it is an unwarranted and unjustified invasion of liberty guaranteed by the Fourteenth Amendment of the Constitution and by Art. 1, Sec. 3 of the constitution of the state of Washington.

Policing of Outside Sources

To insure that safe water is supplied, at times it becomes necessary to take action to avoid contamination of the source of water supply which sometimes is situated outside of the corporate limits of cities and towns. By virtue of Article XI, Section 11 of the constitution of the state of Washington, however, cities and towns are empowered to exercise police power to make and enforce local, police, sanitary, and other regulations only within their corporate limits. In *Brown* v. *Cle Elum* (*10*), the existence of restrictions upon a city in policing a source of supply located outside of its corporate limits was indicated. In that case an action was brought seeking injunctive relief to restrain Cle Elum, a city of the third class, from enforcing its ordinance insofar as it prohibited, or attempted to prohibit, swimming, fishing, or boating in Lake Cle Elum which was situated 6 mi beyond the corporate limits of Cle Elum and from which the city's water supply was taken. The Cle Elum ordinance was enacted pursuant to a statute (RCW 35.24.290 (8)) which vests cities of the third class with authority "to purify and prevent the pollution of streams of water, lakes, or other sources of supply, and for this purpose [they] shall have jurisdiction over all streams, lakes, and other sources of supply, both within and without the city limits." The court held that this statute violated Article XI, Section 11 of the state constitution because the delegation of police power by the state to various municipalities under this constitutional provision is strictly limited to the exercise of that power within the corporate limits of cities and

towns. It should be noted, however, that this decision involved the exercise of police power by a city beyond its territorial limits and *outside of the boundaries of property the city owned beyond its territorial limits* rather than over property actually owned by the city beyond its corporate limits. Nevertheless, by virtue of this decision and the limitation imposed by Article XI, Section 11 of the state constitution, it is doubtful that cities may lawfully exercise police power outside of their corporate limits to protect the city's water supply. The court, however, observed:

> The effect of holding this ordinance invalid will not be, of course, to render the municipalities powerless to protect property owned by them outside of their corporate limits from interference. The law provides several ways in which that protection can be secured; but, without a constitutional amendment, penal ordinances such as the one under consideration here can not be given extraterritorial effect.

Accordingly, to protect a city water supply located outside of the corporate limits of a city, a city could prosecute persons for trespassing on it; it could execute a contract with the county in which the water supply is situated to have the county police it through the sheriff's office or have city employees made deputy sheriffs to provide the necessary police protection; or, if the source of supply were situated contiguous to, or near, a city, the city might be able to annex the area embracing the source of supply in order to exercise police power over it.

Service Outside of City

In an opinion of the attorney general of the state of Washington given to the Bureau of Inspection and Supervision of Public Offices, dated Jun. 18, 1917, it was concluded that the conditions surrounding water service furnished outside of a city or town justify a difference in water rates (*11*). This same conclusion was reached in two decisions of the superior court, from which no appeal was taken to the state supreme court. It was not until 1956 (*12*) that the Supreme Court of Washington was called upon to determine this question. In an action to enjoin the city of Grandview from charging nonresident customers of its municipal water system a rate in excess of that fixed for residents (50 per cent higher than the rate for resident users), the court held that the city was entitled to establish, for rate-making purposes, a separate class consisting of nonresident users, that such rates were nondiscriminatory, and that any rate might be applied to nonresident users as long as the rate was reasonable. The court observed that the cost of rendering service to nonresidents is greater than to residents, and this is true not only in respect to reading of meters, but also in servicing and in repairing lines.

The state supreme court has held that a city owning a water system and furnishing water to users outside its corporate limits, and not the Department of Public Service (now the Public Service Commission), fixes the rates that users outside of the city pay for the service (*13*). The court observed that a 1933 statute empowers a city having a water system to fix the terms for service outside of the corporate limits of a city, whereas a 1917 statute grants the Public Service Commission the authority to fix rates to users outside of the corporate limits of a city. The court concluded that,

because there is an irreconcilable conflict between the two acts, the later act prevails, and that it was the intention of the legislature to give the city owning and operating a water system sole and exclusive jurisdiction over the rates for those outside of its corporate limits, and to take from the Public Service Commission the jurisdiction which it had previously under the 1917 act, even though that act has not been specifically repealed. Accordingly, when a city has applied to the Public Service Commission for relief against what it deems to be excessive water rates exacted from it by another city, the Public Service Commission has declined to assume any jurisdiction.

Sale of Surplus to Nonresidents

Until the 1957 session of the Washington state legislature, by virtue of decisions of the Supreme Court of Washington, the rule was: [1] that a city may sell any surplus water not needed by itself or its inhabitants to nonresidents; and [2] that the right of a city to sell water to nonresidents is always subject to its primary duty to furnish a sufficient supply of water to its own inhabitants (*14, 15*).

At the 1958 session of the Washington state legislature, however, a statute was enacted authorizing cities and towns to enter into a firm contract with any outside municipality, community, corporation, or person, to furnish them with water from the municipal water system regardless of whether the water is considered as surplus or not, fixing the terms upon which the outside distribution systems will be installed and the rates and manner in which payment shall be made. Cities and towns are authorized to sell water within or outside their limits at just and reasonable rates.

In an action for a writ of mandate calling for a referendum on an ordinance to change the rates charged by a municipally owned water system that was financed by revenue bonds, the Supreme Court of Washington held that, as the grant of power to issue the bonds is made to the corporate water authorities and not to the entire city, such an ordinance is not subject to referendum (*16*).

Water Quality

To insure that the desired quality of water is furnished, the Washington Board of Health requires that the following be observed:

1. Clean pipe must be used in water systems. Used pipe with lead in it that has been exposed to spraying such as in fruit orchards or pipe used to convey oil should not be used.

2. Pipes should be laid in soil that is not contaminated.

3. The pipes must be disinfected in accordance with the standard specification of the USPHS.

4. Sample tests must be made of the water in accordance with the standards of the USPHS with such frequency and at such location as to determine the bacteriological content of water. For example, there must be a minimum of one sample test per month in a city of 2,500 or less population, whereas in a city of 25,000 population, there must be at least 25 sample tests per month. The samples used for tests must be representative of the water that is delivered to the customer in the distribution system.

5. If the tests are not made as required or if they indicate the water is not safe for human consumption, failure to take the necessary steps promptly to make the water safe for human consump-

tion may be held to constitute actionable negligence.

6. Chlorine should be left in the pipes at least 24 hr in order for the chlorine to be effective.

7. Thereafter the pipe must be flushed so as to carry away as much sediment and dirt as possible.

8. The sample of water then should be tested.

Gas in Mains

The experience of the city of Grandview in Yakima County has very forcefully and dramatically indicated that administrators of water utilities must be on the alert to detect the presence of gas in water mains and take appropriate action with respect to it. In *Russell* v. *City of Grandview* (*17*), an action was brought against the city and its water department manager for damages and to recover money paid on fire insurance policies. The city of Grandview owns and operates its own municipal water plant; the water was pumped from wells into the distribution system. Combustible methane gas from the wells affected the water pressure. Complaints had been made that there was so much gas in the pipes that it retarded the flow of water. The water utility manager advised the plaintiffs to open the faucets to relieve the gas pressure. In the entrance of a judgment pursuant to the verdict of a jury against the city for $39,000, which was affirmed upon appeal to the state supreme court, it was concluded that it was the duty of the city to ascertain promptly the nature and character of the gas coming from its wells, to determine whether the pressure of such gas was likely to be dangerous to the users of the water, and, if so, to separate the gas from the water before supplying it to its patrons. The court premised the liability of the city upon its active negligence.

Another unfortunate aspect of the Grandview case was the fact that the city had only very limited public liability insurance coverage, and therefore this judgment imposed a very real financial burden upon the city. This fact should serve to alert all administrators of water utilities to the necessity of having adequate bodily injury liability and property damage insurance coverage, regardless of how much care may be exercised in the administration of a water system. Municipalities should review their insurance coverage at periodic intervals to make certain that they have enough coverage to protect the city against possible damage claims.

When the painting of a municipal water tank is undertaken, consideration might also be given to providing an additional safeguard against municipal liability by making the painting contractor an independent contractor. The general test which determines the relation of independent contractor is that he exercises an independent employment, and represents his employer only in the results of his work and in the means whereby it is accomplished. The chief advantage is that although the employer has no right of control as to the mode of doing the work, the employer may reserve the right to supervise the work for the purpose of determining whether it is being done in accordance with the contract without affecting the independence of the relation (*18*). When an independent-contractor relationship exists, a city may not (with the exception of a nuisance) be held liable for negligence in the painting of a water tank. This does not mean, however, that if an

independent-contractor relationship exists, the city should forego adequate bodily injury and property damage insurance.

If a city prefers to perform such work with city personnel, such insurance for a particular risk, such as painting a water tank, has to be purchased if the city does not have a blanket liability policy covering a number of different potential sources of liability. Experience indicates, however, that a considerable saving may be effected by having a blanket policy. The Division of Municipal Corporations in the state of Washington has taken the position that municipalities are not obliged to call for bids in purchasing insurance, although it recognizes that cities can usually effect considerable savings in insurance premiums and obtain additional coverage by doing so. There are two judicial decisions in which it was concluded that the services of an insurance agent or broker furnishing insurance are in the same category as contracts for professional services of a lawyer, physician, engineer, and architect and are not within the purview of statutes that require advertising for bids and award of contract to the lowest responsible bidder (*19, 20*).

Iron Bacteria and Hydrogen Sulfide

The question has been raised whether the presence of iron bacteria in the pipes, particularly after flushing for a fire, renders a city owning the water system liable for laundry stains caused by the water. The question of whether hydrogen sulfide gas should be permitted to be in the water has also been raised. Although it appears that the presence of iron bacteria and hydrogen sulfide in water does not render water unsafe to drink, it would seem that domestic water should also be safe for laundering clothes. A city could protect itself against possible liability for the staining of clothes by iron bacteria by notifying its users not to use it for washing clothes or not to use it for that period after flushing when the danger of staining clothes may be great. Chlorination of water on a continuing basis appears to be the only certain way to insure the safety of water and to eliminate iron bacteria. If hydrogen sulfide gas is present, it should be eliminated by aeration to avoid damage claims and litigation brought about by its adverse effect on the respiratory system.

Pressure and Supply

Complaints may result if water pressure is too high or low, but most pressure complaints arise from the latter. A pressure of not less than 35 psi nor more than 70 psi is usually deemed desirable. Difficulties arise when the pressure is less than 20 psi or more than 70 psi. Inadequate pressure may be caused by a number of factors. The water system may be improperly designed. If, for example, the pipe is too small, there may be an unequal flow of water. In addition, particularly if there are no water meters, users may not have adequate pressure because some users use an excessive amount of water. On the other hand, inadequate water pressure may be the result of an improperly designed structure on the user's property. In order to determine whether the city or the user is at fault, a pressure reading should be taken at the property line and in the structure of the user. Low pressure may be caused by inadequate supply or inadequate pumping.

Usually the user may not be required at his own expense to install a booster pump to increase pressure or a pressure-reducing valve to lower the pressure, because it is the responsibility of the supplier to furnish adequate service. Sometimes booster pumps have affected the pressure of other users adversely and have had to be eliminated.

If the meter reading at the property line shows that the low pressure is due to the pipes inside of the property line, a need for the replacement of these service lines by the user may be indicated.

When water users being served outside of the corporate limits of a city by the municipal water system of that city allege that the pressure is too low because the mains or service lines are too small and should be replaced by the city, it is necessary to determine whether the claims are justified. If they are, the city is not obliged to install larger pipes unless it has obligated itself to do so by contract; this is a matter of negotiation between the city and the users.

If the supply of water is not adequate to meet the demand, a competent water engineer may be engaged to ascertain what steps might be taken to obtain the necessary water supply, or to provide the proper distribution or pumping facilities. This is essentially a management problem. Although it is usually thought that a water system should be designed on the basis of the maximum demand, such a system might be so expensive that it would call for higher rates than the customers would be willing to pay. Where this is true, certain restrictions on the uses of water, such as lawn sprinkling and automobile washing on certain days, might be a solution.

A majority of decisions in sister states hold that a city furnishing water service to its inhabitants is not liable for damages to the owner of property destroyed by fire because the city fails to furnish an adequate water supply or sufficient pressure to extinguish fires. Many of the decisions to this effect are predicated upon the theory that the contract is one between the water company furnishing the water and the municipality and that there is no privity of contract between the water company and the individual inhabitant. These decisions are based on the theory that, in contracting for fire protection, a municipality acts in a "governmental" capacity, and a city may not be held liable for failure to perform a "governmental" duty. In the event the contract does not specifically exclude liability, however, a number of jurisdictions hold to the contrary (*21–24*). This appears to be an open question in the state of Washington.

Liability in Flooding Cases

In a number of cases in Washington, cities have been held liable for damage caused to private residences and to owners of stocks of merchandise in the basement of buildings by the bursting of water pipes and meters. The fact that some basements have not been equipped with drains as required by a city ordinance has been held not to constitute contributory negligence when it is clear that the absence of such drains did not contribute to the damage sustained (*25*). An examination of the cases in which cities have been held liable for damages caused by flooding of premises indicates that cities have sometimes been negligent. Service pipes near the end of the water mains were not made watertight, and escap-

ing water loosened the earth and caused the cap to give way under pressure (*26*).

A city also has been held to be negligent because a bushing in the main was made of a metal of insufficient strength and broke after 10 years, flooding the premises. The foundation of a heavy meter became decayed and the strain of its weight was borne by the weak bushing. The condition of the foundation could have been readily ascertained by an inspection, which the city failed to make (*27*). Thus it appears that the city should inspect its meters at periodic intervals and maintain adequate records in order to be able to prove what inspections have been made if it should become necessary in litigation.

Under the doctrine of *res ipsa loquitur,* a city has been held liable for damage to the plaintiff's property by flooding caused by a broken water main, even though no negligence was proved (*28*).

In an action for damages alleged to have been sustained through the bursting of a water meter in a basement, the "reasonable inspection" that the law requires was defined as not confined to optical observation, but including tests and examinations, "to look upon to examine for the purpose of determining quality and detecting what is wrong . . ." (*29*).

When a city in Idaho built a canal to convey the water of a natural stream through the city, and it was not of sufficient size to convey the stream and overflowed and injured the plaintiff's lands, the city was held liable for damages. It was concluded that the city was beneficially interested in the change of the course of the natural stream, and negligent in not constructing the canal of size sufficient to carry the water in quantities that could reasonably be anticipated (*30*).

Defense of 'Act of God'

It should be recognized that cities may not be held liable for floods resulting from "acts of God," that is, events or accidents that proceed from natural causes and are unusual or unprecedented or cannot reasonably be anticipated and guarded against by the exercise of ordinary care (*31*), unless the city is guilty of concurrent negligence that is the proximate cause of the injury. In *Willson* v. *Boise City,* however, the Idaho Supreme Court held that a city is not exempt from liability for damages sustained through its failure to maintain a sufficient canal to carry the water of the stream, which it had diverted from its natural channel, merely because the overflow was caused by an unusual heavy rainfall or cloudburst such as does not usually occur. It appears that a number of such cloudbursts had occurred in the same locality within the previous 15–20 years.

The court observed that where the overflow of an artificial canal into which a city has diverted a natural stream is caused by a rainfall so unprecedented and extraordinary as to have been beyond reasonable anticipation, the damage is held in law to have been caused by an act of God, and no liability attaches to anyone; but when the rainfall has irregularly and infrequently occurred in a particular locality within the memory of man, and each time has caused heavy freshets, it can reasonably be expected to occur again, and hence is not an act of God and does not discharge the city from liability.

The liability that may result to cities by not keeping streets in a reasonably safe condition and free from obstructions, or by not guarding dangerous conditions incident to the operation of water systems, is quite obvious. When a dangerous condition is created on a street by a third person (not a city employee acting within the scope of his employment), that third person may be directly liable for personal injury or property damage. The city also may be held liable, when chargeable with notice of the condition resulting from the negligence or wrongful act of a third person, if appropriate action is not taken to protect the public.

Reservoirs

The construction of a reservoir in Volunteer Park in Seattle for the storage of city water on a side hill, which had a 56-ft embankment as the only protection between the homes of the complainants and the impounded water, was enjoined on the ground that it constituted a nuisance (*32*). The court stated that the test of whether a reservoir is a nuisance turns on whether the complaining property owners are under a reasonable apprehension of danger. The question of the reasonableness of the apprehension depends not only on the probable breaking of the reservoir, but also on the injury that would ensue to human lives and property if it should break. The court concluded that the construction of this reservoir would cause a most serious depreciation of property values within the affected area and that it would be an obstruction to the free use of property, as it would interfere with the comfortable enjoyment of life and property and be a nuisance because it annoyed, injured, and endangered the comfort, repose, health, and safety of the complainants. Finally, the court observed that the fact that the existing reservoir at Volunteer Park had occasioned no damage was far from conclusive proof that a new and much larger reservoir, constructed under different conditions, would be equally harmless.

Although it is true that a court of equity will enjoin a city from continuing to discharge impure water into a stream from a reservoir if an overflow to the injury of riparian owners results, a city may acquire a prescriptive right to discharge impure water semiannually, when it cleans its reservoir, if knowledge of and acquiescence to this practice could be presumed (*33*).

Free-Water Contracts

From time to time citizens have viewed, with some degree of suspicion, contracts executed by cities to furnish water free, and frequently have questioned the wisdom of executing such contracts. Nevertheless, the Supreme Court of Washington has held that a city that owns its own water system may furnish water free for municipal or charitable purposes (*34*).

In a contract executed in 1903 between the city of Bellingham and Whatcom County, the city promised to furnish water free to the county courthouse for as long as certain real property, or the greater amount of it, remained off the tax roll. When the old courthouse was abandoned the new courthouse, occupied in 1950, required a much greater water supply. Bellingham contended that the contract to furnish water free was no longer valid because the tax lien upon the property became void upon the passing of title to the city, and therefore the promise to strike the property from the tax roll was no consideration for the prom-

ise to furnish the water to the county free of charge. The court held, from the fact that the city and county made a contract, that they, in good faith, believed the tax lien was a valid one. This belief, coupled with the doubtful state of the law on the subject at the time the contract was executed, enabled the city to remove the property from the tax roll in return for its promise to furnish water to the county. The court concluded that the test, when the existence of consideration is to be determined, is not so much whether a claim is really doubtful as it is whether the parties so consider it (*35*).

It would seem that cities should ponder very carefully the full implications of entering into agreements to furnish water free of charge, as such undertakings may, in the long run, prove not to be compatible with the public interest or to reflect sound public policy. A number of cities now feel that some contracts with industrial users have been made for too long terms; that it would be better to have somewhat shorter terms; and that perhaps the industrial users should agree in such contracts to assume a measure of responsibility for the maintenance and replacement of the water mains that serve them.

Delinquent Accounts

Under existing law, cities owning their own water systems have a so-called statutory lien against the premises to which water has been furnished for 4 months, charges therefore being due or to become due, but not for any charges more than 4 months past due. This lien is enforceable only by shutting off the service from the premises until the delinquent charges are paid. A city is not given any lien in the technical and usual sense of that term —that is, the property served is not regarded as security for payment of the claim. This lien is not like tax, assessment, judgment, mortgage, or mechanics' liens, which operate upon the property directly and are satisfied from it. The city cannot, by any form of procedure, collect its charges from a forced sale of the property itself.

Also, under existing law, the owner of the premises or the owner of a delinquent mortgage may give written notice to the water utility manager of a city to cut off service to such premises accompanied by payment or tender of payment of the then delinquent and unpaid charges for such service, together with the cut-off charge, whereupon the city or town shall have no lien against the premises for charges for such service thereafter furnished, nor shall the owner of the premises or the owner of a delinquent mortgage thereon be held for the payment thereof.

Statutory Water Liens

An appreciation of the background of lien legislation is of material assistance in understanding the thinking behind the existing water lien legislation. By virtue of a 1909 statute, cities owning their own water works were first granted a lien for delinquent water accounts against the premises to which the service had been furnished, but there was no limit on the length of time that a water lien might cover, nor was the owner of the premises, while under a lease, or the owner of a delinquent mortgage, authorized to protect himself by giving a notice to the city to cease providing water service. The injustice of the 1909 law was graphically demonstrated by the decision in *McCormacks, Inc.* v. *Tacoma* (*36*), in which the court held that the city of

Tacoma was not required to serve a new owner until the city's claim of over $2,000 created by service rendered to previous owners of the property had been fully paid. The remedy ran against the premises served as well as against the tenant using the water. The effect of this decision was to compel one person to pay for water service that had been supplied to another.

To mitigate the harsh rule laid down in *McCormacks, Inc.* v. *Tacoma, supra,* in 1933, the legislature amended a 1909 act that limited the city's lien to 4 months' delinquent charges and gave the owner of the premises or of the delinquent mortgage the right, by written notice to the water utility manager, to have the water service cut off. The effect of the 4-month rule provided for in this 1933 amendment is that, if a city continued after Jun. 7, 1933, to provide water service for more than a 4-month period when a water bill was unpaid for that period of time, it would do so at its own peril so far as the imposition of a water lien were concerned. This 4-month rule does not invalidate the amount of the water bill for a period in excess of 4 months, but simply limits the machinery available for its collection; other methods are available for the collection of such delinquent accounts, such as garnishment, as such accounts constitute debts. It should be noted that by this statute a city is permitted not only to cut off the supply of water to those persons who have delinquent accounts for a period of 4 months, but also, by virtue of this statute, a city may refuse a resumption of service until the delinquent charges are paid.

It is noteworthy that the Supreme Court of Washington has held that the 1933 amendment to the 1909 act operates only prospectively and not retroactively, and the 4 months' limitation does not apply to charges that became delinquent prior to June 7, 1933, the effective date of the 1933 amendment. In reaching this conclusion, the court stated that to do otherwise would impair the vested right, definitely granted, of a city to extend credit for more than 4 months prior to June 7, 1933.

It should be noted that in *Home Owners' Loan Corporation* v. *Tacoma* (*37*), the court held that the statute of limitations does not apply to delinquent water accounts or to the right of the city to refuse its water service in order to enforce collection of its delinquent water accounts. The court also concluded that the fact that a city, after having cut off the water supply, voluntarily resumed service without compelling the payment of delinquent charges, does not operate as an estoppel or waiver of its right to collect charges made prior to the cutoff, and the city was entitled to have those delinquent charges paid that accrued prior to the effective date of the 1933 amendment before continuing to supply water to the premises.

Wrongful Shutoff

At the same time it should be recognized that a city may be held liable for damages for a wrongful shutoff. Water service may not lawfully be cut off to enforce payment of charges which are discriminatory, erroneous, excessive, or in violation of the terms of a contract. Shutting off a supply of water has resulted in actions being brought for damages against the supplier. In Washington, a water lien statute provides that, "in the event of a disputed account and tender by the

owner of the premises of the amount he claims to be due before the service is cut off, the right to refuse service to any premises shall not accrue until suit has been entered by the city and judgment entered in the case."

Because shutting off the water for the purpose of repairs, maintenance, or new connections frequently occasions complaints of interference with cooking, meals, bathing, plumbing, washing cars, sprinkling lawns and gardens, and other activities, the users should be notified of the projected shutoff by telephone or by personal calls in smaller towns; in larger cities shutoff notices may be placed in the newspapers.

Emergencies may arise that require shutting off the water for some time. Care should be exercised, however, not to have the water shut off for an inordinate time.

Private Mains in Public Streets

To avoid many legal and practical difficulties, if a city decides to permit an operator of a well to lay water pipe under the city streets to provide water to various users, the city should enter into an agreement by which the operator agrees to convey title to the pipe to the city on certain terms, and the city should reserve the right to allow other users to connect with the pipe. The city should be the sole supplier of the water when it ultimately operates the system. No exclusive franchise should be granted. The agreement also should provide that the pipe be approved by the city engineer in accordance with appropriate engineering standards in view of the size of existing and future installations. The city could issue a temporary permit for the installation of the necessary water pipe and distribution system and reserve the right to operate it and to take it over as a part of the city water system; it would also be desirable to include in the permit the other essential provisions of the agreement.

Although there is a split of judicial authority on the question of whether one who constructs a private utility under a street with the permission of the city owns the utility and may decline to permit abutting property owners to connect to it, there appear to be no judicial decisions of record on this question in Washington. The weight of judicial authority appears to be that a person who has been granted permission by the city to construct, at his own expense, a private utility in the street, is entitled to its exclusive use unless the city had reserved the right to have others connect to it when the permission was granted. Hence the need to indicate carefully the terms under which private water installations may be placed in city streets is quite apparent.

In a number of judicial decisions, the announcement has been made that a dedication of a street reflects only an intention to dedicate it for highway purposes and to reserve every other right, and does not necessarily indicate an intention to dedicate privately owned utilities that are laid in the street to a public use (*38*).

Many of the problems of both municipal and privately owned water systems as well as private companies could be resolved by the adoption and enforcement of proper platting and subdivision rules and regulations.

Construction Contracts

If the mayor or legislative body of a municipality or the agency transact-

ing the business of any municipal corporation fails to obtain the contractor's performance bond, which is called a contractor's contract bond in the state of Washington, the municipality may be held liable to the laborers, mechanics, subcontractors, and materialmen to the full extent and for the full amount of all debts contracted by the contractor. These Washington statutes require that when a city or town contracts with any person to do work for the municipality, it shall require the contractor to make, execute, and deliver a good and sufficient bond with two or more sureties, or with a surety company as surety, with the condition that the contractor will faithfully carry out all of the provisions of the contract and pay all laborers, mechanics, subcontractors, materialmen, and suppliers for carrying out the work.

In cities and towns, the governing body may, by general ordinance, fix and determine the amount of the bond and to whom it shall run, but the amount may not be fixed at less than 25 per cent of the contract price of any work or improvement. Nevertheless, most of the larger cities require the bond to cover the complete value of the contract, as they have found from experience that such a guarantee is valuable not only because it protects the city against any loss, but also because it insures that the bonding company will be efficient in its scrutiny of the moral and financial stability of the contractor.

Contractors' contract bonds guarantee the carrying out, according to the specifications of the contract, of the construction or repair and any agreements covering the performance of specific services involving the use of labor and materials. The contractor's bond can also cover contracts for the furnishing of material and fixtures and specific services such as surveying.

A contractor's contract bond carries both a moral and a financial guarantee. It guarantees that the contract will be fulfilled according to plans and specifications. A contractor may and should be honest, and yet be unable to fulfill the conditions of his contract. It is not enough that a contractor be honest; it is also essential that the contract be performed properly.

The bond must be filed with the city or town clerk or with the comptroller. Any person performing services or furnishing material to any subcontractor has the same right under the provisions of the bond as when the services and material are furnished to the original contractor. The bond does not, however, apply to any money loaned or advanced to any contractor, subcontractor, or other person in the performance of the work (*39*).

The legal problems and responsibilities that may arise incident to the ownership, operation, and maintenance of a water system can be numerous and varied, but those that have been considered are those that experience has shown to be most important and merit the attention and careful consideration of all administrators of municipal water systems.

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Radio Communications for Water Utilities

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RADIO, television, telephone, telegraph, and teletype are so much a part of everyday living that few people realize their importance. Early this year the Federal Communications Commission (FCC) reported that Americans had almost 63,000,000 telephones and made 250,000,000 telephone calls daily; that 23,000 customers were connected by teletype lines; that the telephone system use radio in more than half of its intercity links; and that the FCC had over 2,000,000 radio authorizations on its books. Broadcast service authorizations, including standard amplitude modulation, frequency modulation, and television stations, numbered more than 8,500. And for each station licensed in the broadcast service, there are about 50 radio authorizations of other kinds, serving the public, industry, commerce, and individuals (*1*).

Licensing of Utilities

The FCC has jurisdiction over all radio stations except those used by the federal government. The FCC allocates radio frequencies, establishes technical standards, and prescribes radio operating rules. Organizations having similar types of operation are classified and grouped into specific radio services, each governed by a different part of the FCC rules. Examples are: public safety, under Part 10; amateur, under Part 12; and industrial, under Part 11. These radio services are further subdivided; for example, industrial radio services are divided into power, petroleum, forest products, and other, similar, services. Groups of radio frequencies, called bands, are assigned to each subdivision, and all licensees in a particular service share these frequencies.

Water utilities are eligible for licensing in the power radio service, along with the electric, gas, and steam utilities. These four are termed power utilities, because each delivers a product that can be metered.

Power radio service licensees have pioneered in the use of ultrahigh-frequency mobile communications; microwave systems for control, telemetering, and communications; and unattended radio stations for automatic reporting of power line failures. The field of private radio communications is so broad that this discussion is purposely limited to consideration of mobile-radio dispatching systems.

The growth of two-way radio use by water utilities in California has matched or exceeded that in the rest of the country. In 1947, there were thirteen utilities licensed to use mobile-radio dispatching systems in California. As of April 1958, California had 148 licensees in the power radio service, operating 458 base stations and thou-

sands of mobile stations. Of these licensees, 92 were municipal water departments, private water companies, or irrigation districts.

Nationally, in 1947 there were 250 utility licensees. Now (October 1958) there are more than 2,000 licensees, operating 8,891 base stations and 124,058 mobile stations, or a total of 133,039 stations operating on 42 frequencies in the three bands allocated for the exclusive use of power utilities (*2*).

Why have the power utilities invested so heavily in mobile-radio dispatching systems? Those companies now using mobile radio are well aware of its many advantages. Those that are not using radio in their operations have probably wondered how to use this valuable tool. How does it fit in? What does it cost? Will it pay? These valid questions should be answered before any utility invests its time and money in a radio system.

Advantages of Radio

If operating conditions are right for mobile-radio dispatching, and it is used correctly, service can be improved and operating costs cut.

Service improvement occurs in many ways. A truck can be dispatched while the customer is still on the telephone, and be at his door within a few minutes. Distant customers get better service because trucks working in their areas can be contacted immediately. Emergencies can be handled rapidly. If a driver is lost or is given a wrong address, it takes only a few seconds to radio in for additional instructions. This eliminates the necessity for use of a customer's telephone by utility employees.

Operating costs are cut by eliminating the telephone expenses between the driver and dispatcher and the time wasted by the driver in locating a parking space and a pay telephone. Fuel and tire costs go down because fewer miles are driven per job. Truck breakdowns can be repaired sooner, saving driver and equipment time. Employee morale is improved because two-way radio promotes teamwork, and puts the men in closer touch with their supervisors and each other. Cost surveys have shown that a radio-equipped vehicle increases a driver's productivity by 20–40 per cent (*3*).

Two-way radio does not solve all problems, however. Many factors must be considered before a utility can be sure that it will be able to use two-way radio successfully.

Definitions

Mobile-radio dispatching is a broad term describing a number of different types of radio communication between a driver and his home base, or between drivers in different vehicles. Of these, a private two-way radio system offers the maximum in service improvement, cost cutting, and flexibility. Not all utilities can justify the investment required to install such a system. There are four alternative means of mobile radio communications, each designed to do a specific job at a set price, and each having limitations.

Some of the terms necessary to a discussion of radio communications are defined below.

1. A *base station* includes all the radio equipment that makes up a fixed station, and is normally located at the utility operating headquarters.

2. A *mobile station* consists of all the radio equipment mounted in a car or truck.

3. A *frequency* is one particular location within the whole radio spectrum.

4. A *channel* is a frequency plus additional side frequencies which represent the amount of radio spectrum required to transmit a voice or tone signal.

5. A *band* is a group of channels.

One-Way Signaling

The first and simplest means of mobile-radio communications is the one-way signal method. This service, provided by either the telephone company or a private company, requires only a small radio receiver in the car or truck. The receiver is equipped with a buzzer, a light, and a switch.

When the dispatcher has information to relay to the driver, he calls a telephone operator and gives her the vehicle's call number. She then transmits a radio signal to the vehicle's receiver, which sounds the buzzer and flashes the light. The driver pushes the switch, resetting the receiver for the next call, and proceeds to the nearest telephone to call the dispatcher. If the driver is away from the vehicle when the radio signal is received, the light flashes until he returns and operates the switch.

The equipment is owned, installed, and maintained by the serving company. Monthly costs vary, but usually a flat rate covers the first 40 calls per month, with an additional charge for each additional call.

Paging

Slightly more complex is the paging service, usually available only in the larger cities. It is offered on a subscription basis by private companies. Subscribers are equipped with small pocket receivers, a little larger than a package of cigarettes. Each subscriber is assigned a separate call signal number.

To contact a subscriber who is away from his own telephone, his office simply telephones the paging service headquarters, where operators send out the appropriate call signal number by radio. In a typical system this signal is repeated every 1½ min for about ½ hr, and is the subscriber's cue to call his office.

Because all call signals are transmitted on the same frequency, the subscriber must listen in every 15 min or so to sort out his signal from the others. Also, because each signal is sent separately and the total time cycle is about 1½ min, only a limited number of subscribers can be accommodated. The average subscription cost is $5–$20 per month.

Mobile Telephone

The third method is the extended, or mobile, telephone. This is a form of two-way radio which allows communications by telephone between a vehicle and any regular telephone, as well as between two vehicles.

The mobile equipment installed in the vehicle consists of a radio receiver and transmitter, antenna, dialing device, and telephone instrument. It is owned, installed, and maintained by the telephone company. Monthly charges are about $30–$40 per month, which includes 20 calls. All calls in excess of the first 20 per month and long-distance calls are charged extra.

Anyone wishing to call a vehicle equipped with a mobile telephone calls the long-distance operator from any telephone, asks for the "mobile operator," and gives the telephone number of the vehicle. The mobile operator sends a coded tone signal from the radio control terminal station. This signal rings a bell and flashes a light in the vehicle called. The driver resets

his light and then speaks to his caller as though using a regular telephone.

Because all mobile telephones in a given area operate on the same frequency, it is often necessary to wait one's turn. In an emergency this is a serious disadvantage.

Answering Service

A fourth method, combining telephone and two-way radio, provides most of the advantages of radio communications, without the expense of a base station. It is an answering service supplied by a private company, which may also provide the mobile equipment. Each subscriber equips one or more of his vehicles with a mobile station. The subscriber is assigned a special telephone number, which is listed in the local directory. Calls for the mobile stations are placed to this number, which is answered by the service company operator, who then transmits the message by radio. The mobile unit answers the service operator, who relays the answer to the telephone caller. There is no direct contact between the mobile station and the telephone caller. The service company charges a flat rate per mobile station.

Any of the four mobile communication methods described above can be used by a utility if the services are available in the community. The companies offering these services are licensed by the FCC, and the utility therefore does not need a license.

Two-Way Radio

Private two-way radio requires that the user be licensed. Two-way mobile radio, strictly defined, is radio communication between stationary and moving radio stations or between movable or moving stations, with both stations transmitting and receiving in turn. A two-way radio system usually consists of a base station and its affiliated mobile stations, all operating on one frequency.

The base station equipment includes a transmitter, receiver, loudspeaker, control unit, microphone, a tower or mast of considerable height, an antenna, and a coaxial transmission line between the antenna and the transmitter and receiver. Each mobile station consists of a radio receiver and loudspeaker, a transmitter, control unit, microphone or telephone hand set, and an antenna.

Operation of a two-way radio system is fairly simple. At the operating headquarters, the dispatcher's voice is amplified by the remote-control unit, and carried to the transmitter through a coaxial cable or a leased telephone circuit, because the transmitter is usually some distance from the headquarters. The transmitted signal is radiated to the mobile-unit operator, who answers the dispatcher by operating his own transmitter to send his voice to the base station.

A usual message from dispatcher to mobile unit takes about 10 sec. Many utilities have adopted word or number codes to shorten the time on the air.

Of the five types of radio communication described above, two-way radio has proved to be the most popular, as shown by the rapid growth in its use. The reasons are many, but perhaps the most important one is that the entire system is under operational control of the user at all times, and thus is not affected by strikes of the telephone company or other serving agency.

Installation of a System

If a company has decided to install a two-way radio system, what are the

steps it should take? First, the utility must get a license and a frequency assignment from the FCC. The application must be complete, specific, and show clearly that the equipment is needed. The FCC license application requests information about the base station location, area of operation of mobile stations, proposed equipment, power, antenna height, and requested frequency (*4*).

Accompanying the application must be evidence of frequency coordination. This can be: [1] a report, based on a field study, showing the extent of probable interference to other stations operating on the requested frequency within 75 mi of the proposed station and to all stations operating on adjacent frequencies within 35 mi of the proposed station, and stating under oath that all such stations have been notified of the applicant's frequency request; or [2] a statement from a frequency advisory committee, recommending the requested frequency.

The license gives the utility exclusive control of its equipment as long as it is operated according to the rules. No one else can apply for a license for a utility. The utility is the one who will operate the radio system, is eligible for the license, and is held responsible by the FCC for proper operation and compliance with FCC rules; therefore, the utility must apply for the license. This is true whether it leases or buys radio equipment. Furthermore, no licensee has a private channel; radio waves are public property, and the utility's radio frequency must be shared with other users.

How does a company determine what frequency is best for its operations? Primarily, this decision is based on the range of operation desired. Frequencies in the low band—30–50 megacycles (mc)—are used for a 25–50-mi range. High-band frequencies—150–160 mc—allow a 15–20-mi range. Ultrahigh frequencies—450–460 mc—give only 10–15 mi. These ranges are necessarily approximations, as they vary widely, depending on the height of the base station antenna, transmitter power, type of terrain, and similar factors.

An important step is to determine the proper equipment. All radio reception depends upon three factors: receiver sensitivity, transmitter power, and relative heights of the transmitting and receiving antennas. Proper engineering of the system will balance all three factors against the utility's operating needs.

Receiver sensitivity is equally important in base or mobile stations. Sensitivity should be high enough to permit two-way operation under the worst conditions. Transmitter power required should be based on an engineering study of the topography of the operating area. Probably the most important factor affecting adequate reception is base station antenna height. A high location, such as a mountain top or tall building, will do more to insure good reception by both base and mobile stations than will a powerful transmitter.

Mobile antennas are usually of the "whip" type. They are designed for one specific frequency and should be installed as high on the car as practical. The best location is on top of the truck cab, or, on passenger cars, on the deck behind the rear window.

Another consideration in the installation of a two-way radio system is to decide whether the utility should buy or rent its equipment. Either way there are advantages. Many private communications service companies, and

some of the equipment manufacturers, will rent a utility everything it needs for a complete system. This is done by a lease contract, which usually runs for 5 years. Monthly charges are a set percentage of the base equipment price plus a percentage for carrying charge. If the leasing company installs the equipment, the installation cost is added to the base cost and forms part of the basis for the monthly charge.

If it is decided to buy the equipment outright, the fixed monthly charge is avoided, and the installation will be the utility's own property, allowing more flexibility in operations. Which of these methods would be the more economical must be determined by the individual company on the basis of local conditions.

Costs

Equipment costs are fairly uniform, because competition between equipment suppliers is high. A simple 60-w transmitter, designed for local control, costs approximately $900. A 250-w transmitter, also for local control, costs approximately $2,200. A remote-control unit for either size of transmitter adds $300–$400 to the basic price. An additional component that makes it possible to dial mobile units individually would add another $200–$300. The base station and other fixed equipment will have a useful life of 10–15 years.

A combination mobile unit, containing both receiver and transmitter, is priced in the range of $500–$700, depending on the power output rating of the transmitter. Selective equipment for the unit to receive dialed calls costs another $200. Mobile units need replacing every 7–10 years.

Installation costs vary considerably. Mobile-unit installation costs normally run $30, but may be $40–$50 for special cases. A good technician can install two or three units a day. Base station installation costs average about $100, with antenna installation extra.

Maintenance

The same companies and manufacturers that sell or lease equipment usually offer complete maintenance contracts. Base station maintenance on such a contract costs $20–$30 a month. This figure covers the labor costs for unlimited service on a 24-hr basis, and may or may not include parts.

Maintenance of mobile units is normally done during the regular work hours, as failure of one unit does not seriously affect the whole system. Besides, most utilities have spare units for temporary or emergency use. Maintenance contracts usually charge $6–$9 per month per unit.

If the utility decides to do its own maintenance, it will be among the minority. A recent survey showed that only 20 per cent of the licensees maintain their own equipment, and 80 per cent of these have less than ten mobile units. The heavy investment required to set up and man a service shop on a 24-hr basis evidently has convinced many utilities that it is cheaper to have the work done by contract. If, however, a utility considers setting up its own maintenance shop, it should first consider these interesting figures. One serviceman can maintain 100–150 mobile units if they are brought in to the shop. If he must do the maintenance in the field, this number is halved. To maintain a base station and 100 mobile units on a 24-hr basis requires four men, three vehicles, 1,500–2,500 sq ft of shop space and $20,000–$40,000 in equipment. Average salaries are $550 a month, to which

must be added the costs of sick leave, vacations, retirement, and turnover. Vehicles cost about $150 a month, including depreciation. Thus the total cost for the first year could exceed $100,000.

Protection of Investment

How does the utility protect its investment and right to use its radio? From the costs cited above one can see that two-way radio is not a toy. A radio system is built of highly complex, costly units of precision equipment. Nevertheless, an entire installation could be made obsolete or unusable overnight, if the FCC changed the frequency assignment or decided to reallocate the frequency to another service.

All utilities that use radio face this same problem. The solution lies in cooperative action through the national organization that can speak for all power radio service licensees. This organization is the National Committee for Utilities Radio (*5*).

During World War II, the FCC requested the radio industry to establish a Radio Technical Planning Board (RTPB), whose purpose was to plan for the orderly development of the many new and varied types of radio services that could be expected to appear when the war ended. Committee 4, Panel 13, of the RTPB represented the electric, gas, and water industries. It was this committee that, at the FCC general allocation hearing in 1944–45, was able to obtain for the utilities the frequencies and operating rules that, for the first time, recognized the power utilities' need for radio.

Committee 4 functioned until 1949, when the RTPB was disbanded. The National Committee for Utilities Radio (NCUR) was immediately organized to replace Committee 4, and to cope with the numerous problems arising from the rapidly expanding use of mobile radio.

NCUR membership includes representatives from seven national trade associations, including the American Public Power Association, American Gas Association, and AWWA, and delegates from ten regional utility radio committees, representing the individual licensees. Each regional committee is composed solely of power radio service licensees in a particular area. For example, the Southwest Committee for Utilities Radio (SCUR) includes all licensees in California, Arizona, Nevada, and Utah. The SCUR meets annually, usually in the spring.

Equipment manufacturers or their representatives are not eligible for membership in either the national or regional committees. All power radio service licensees are automatically members of their appropriate regional committees.

Officers and members of the NCUR and its regional organizations receive no pay or expenses for their committee work other than that furnished by their respective employers. There are no dues; neither NCUR nor its regional committees have a treasurer. Because of the large amount of time and energy necessary for preparing and filing of briefs before the FCC, however, the NCUR does employ legal assistance. The cost of this legal aid is borne by voluntary contributions from the power radio service licensees. Each licensee is asked to contribute his fair share of this legal-aid expense, which is very nominal. For example, if the licensee operates one base station, his share is $15. Slightly more

than half of the licensees responded in 1957–58. Each licensee who shares in this expense not only assists the work of the NCUR but receives a direct return in the form of quarterly reports and special news releases, which keep him informed of developments affecting his use of radio.

Functions of NCUR

The most important function of NCUR is to provide frequency coordination to its members. In filing an application with the FCC for a station license, a utility is required to file a report based on a field survey and a statement under oath that it has notified all affected licensees or furnish a letter from the frequency coordinator in its region recommending the requested frequency. Frequency coordinators do not assign frequencies; only the FCC can do that. Because the commission is keenly aware of the difficulty in finding interference-free channels, it relies heavily on the advice of the regional frequency coordinators. NCUR pioneered in this field, and developed the "Underhill Plan" for orderly frequency assignment, now used by practically all industrial radio services.

NCUR also assists the new licensee in setting up and maintaining standard operating procedures, as required by the FCC. To insure complete coverage of this requirement, NCUR publishes a guide which is furnished to members free of charge (*6*).

NCUR represents its members before the FCC, giving them the force and protection of a united front when their interests in the use of radio are threatened. It keeps a watchful eye on all FCC dockets or inquiries, and analyzes their effects on utility radio.

The present high state of development of power utility radio is largely the result of much hard work by the NCUR and its regional groups. It has labored unceasingly to insure the continuance and improve the usefulness of radio for its members. It has appeared and filed comments in every FCC docket that might affect the power radio service in any way. One such docket is No. 11997, in which the FCC is studying the utilization of all radio frequencies between 25 and 890 mc. The FCC action resulting from this inquiry may result in a shift of all television stations from the very-high-frequency band (Channels 2–13) to the ultrahigh-frequency band (Channels 14–83). Other frequency reassignments may result in moving many of the various radio services to entirely different parts of the radio spectrum, if such reallocation can be shown to be in the "public convenience, interest, or necessity." The NCUR has filed briefs with the FCC, showing the present usage of channels allocated to the power radio service, and predicting a 79 per cent growth in the next 10 years, based on data collected from all NCUR members.

Of urgent interest are the FCC report and order in docket No. 12295, requiring all Power Radio Service licensees in the 30–50-mc band to comply with new "split-channel" requirements by Feb. 1, 1959. For utilities using equipment manufactured prior to 1952, this order means an immediate investment of $50–$100 per mobile unit, and a higher amount for each base station. From the commission's standpoint, the change is justified because it nearly doubles the number of channels allocated to the power radio service. NCUR has agreed with the FCC

because of the severe congestion on present channels (*7*).

From the foregoing survey, it is obvious that the power radio service is a rapidly changing, expanding activity. Utility radio users depend on their radio systems to aid in the difficult job of supplying the water needs of a growing population. The future use of radio depends on how well utility interests are represented before the FCC. NCUR has the backing of AWWA, but this is not enough. It needs and wants the support and participation of each utility user of radio through its regional committee, in order to protect utility interests effectively.

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Cooperative Studies on Laboratory Methodology

Harry P. Kramer and Robert C. Kroner

A contribution to the Journal by Harry P. Kramer, Chief Training Program, and Robert C. Kroner, Chemist, Analytical Reference Service, both of the Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

THE Analytical Reference Service of the Robert A. Taft Sanitary Engineering Center is a voluntary association of member organizations responsible for the conduct of laboratory programs. Its purpose is the evaluation of laboratory methods in the field of sanitary engineering. The present membership consists of 50 different agencies. A list of these is shown in Table 1. Membership, acquired by written request, imposes no obligation upon the members but is an indication of their desire to participate in the cooperative study of laboratory methodology through the analysis of specially designed samples. This mechanism provides:

1. Statistical evaluation of procedures, including precision and accuracy
2. Evidence of the need for further development of methods or entirely new approaches
3. A framework for broad-scale evaluation of new methods
4. A clearing house for data and information through which members can compare their own procedures and results with the work of similar laboratories.

Preparation of Samples

Preparation of samples for the Analytical Reference Service is done in such a manner as to guarantee, to the fullest extent possible, the desired concentrations of constituents. The substrate water for each sample is prepared by passing distilled water through a laboratory deionizer. The water is essentially free of heavy metals and ammonia. The chemicals to be added are removed from protected reagent bottles and dried, each according to specific requirements, and stored in a desiccator. If the amount of any chemical to be added is sufficiently large, the chemical is dissolved in a small quantity of water after weighing and is then added to the substrate. If this procedure is not feasible, measured volumes from a stock solution of appropriate concentration are added to the substrate.

Because aliquots of a single sample are distributed to all members participating in a particular study, the total volume is rather large. For the most recent reference sample, 180 liters (approximately 40 gal), were prepared. The batch vessel used is a 50-gal polyethylene tank calibrated at 20-liter intervals. The tank is set on a specially built table equipped with casters so that it can be placed directly under the deionizer for collection of the substrate water and can be moved easily around the laboratory. The

table is also equipped with a large magnetic stirrer, which uses a 6-in. stirring bar for complete mixing of the sample and for agitation while the sample is being dispensed into aliquots.

Aliquots of the master sample are placed in polyethylene shipping bottles. One aliquot is chosen at random for analysis in this laboratory. This analysis is made to insure that no significant errors have been made in sample preparation and to uncover possible difficulties not anticipated during sample design and preparation.

Upon completion of sample preparation and check analysis, a letter de-

TABLE 1

Analytical Reference Service Members as of Feb. 1, 1959

State Agencies

Arizona Department of Health
Arkansas Board of Health
California Department of Public Health:
  Berkeley
  Los Angeles
California Department of Water Resources:
  Sacramento
  San Bernardino
Colorado Department of Public Health
Connecticut Department of Health
Florida Board of Health
Hawaii Department of Health
Idaho Board of Health
Illinois Water Survey Division
Kentucky Department of Public Health
Louisiana Department of Health
Maryland Department of Health
Maryland Water Pollution Control Commission
Michigan Department of Health
Minnesota Department of Health
Missouri Department of Public Health and Welfare
Montana Board of Health
Nebraska Department of Health
NewHampshire Water Pollution Commission
New Jersey Department of Health
New Mexico Department of Public Health
New York Conservation Department
New York Department of Health
North Carolina Stream Sanitation Committee
Ohio Department of Health
Oregon Board of Health
Pennsylvania Department of Health
Rhode Island and Providence Plantations Department of Health
South Carolina State Water Pollution Control Authority
South Dakota Board of Health
Tennessee Stream Pollution Control Board
Texas Department of Health
Utah Department of Health
Vermont Department of Health
Vermont Water Conservation Board
Virginia Water Control Board
Washington Department of Health
West Virginia Water Commission

Municipal Agencies

Los Angeles Department of Water and Power
Chicago Department of Water and Sewers
Metropolitan Water District of Southern California

Federal Agencies

Army Chemical Center, Edgewood, Md.
Sanitary Engineering Division, 13th Naval District
US Geological Survey, Department of the Interior:
  Columbus, Ohio
  Sacramento, Calif.
  Washington, D.C.
  Denver, Colo.

Universities

Department of Applied Biology, Georgia Institute of Technology
Department of Chemistry, Purdue University
Department of Civil Engineering, Case Institute of Technology
Department of Sanitation, Rutgers University
Graduate School of Public Health, University of Pittsburgh

Industrial

National Aluminate Corporation
Monsanto Chemical Co.

scribing the sample makeup and outlining the work required is sent to all members. The letter includes a return form on which the member indicates by check mark whether or not he wishes to cooperate in the particular study. Sample portions are then shipped simultaneously to all laboratories that have requested them. Instructions regarding analysis and a form for reporting the analytical data are included.

Standard report forms are used to facilitate data handling and to insure inclusion of all necessary information. Forms are also supplied for comments on the various analytical procedures used. The quantitative composition of the sample, in terms of the amount of each substance added, is mailed to each member as soon as his report is received at the center. Whenever gross errors appear in a report, the member is notified so that calculations or dilution factors may be rechecked. When reports have been received from all agencies participating in a study, a summary of numerical values is prepared and distributed. In order to protect identity, a code number, used both in this summary and in the final report, is assigned to each participant for each study.

Reports

Preparation of the final report is the most difficult feature of these studies. A large accumulation of data on analytical results obtained under conditions of controlled variables may invite extensive statistical treatment. It is felt, however, that the parameters employed should instead be kept at a practical level so that the interpretation and significance of the data may be readily apparent to all personnel in each member laboratory.

Sample Types

The samples supplied to date by the Analytical Reference Service have been chosen and designed to be of maximum value to the largest number of members. A description of them is given in Table 2.

Evaluation of Laboratory Methods for Analysis of Minerals in Water

Sample Type I (water, mineral) has been distributed twice in approximately 2 years. In the second study it was designated as Sample Type I-A. Determinations requested for this sample are run routinely in many laboratories for characterization of raw or finished waters. The results of studies on Sample Type I-A are summarized below.

Calcium

For many years calcium determinations were run almost exclusively by a gravimetric procedure or by a combination gravimetric–volumetric procedure. On Sample Type I, eleven laboratories used one or the other of these procedures and thirteen employed some modification of the EDTA titration. For the Type I-A sample, 22 groups used an EDTA procedure and only five used the older gravimetric–volumetric method. For the EDTA procedures the standard deviation was 4.2 mg/l (from a concentration of 120 mg/l), whereas the volumetric

permanganate procedure had a standard deviation of only 2.1 mg/l. Although the latter method gives better results, the EDTA methods are strongly preferred by many for their simplicity and speed.

TABLE 2

Sample Types and Contents

Sample Type	Content and Testing Method
I	(water, mineral) calcium, magnesium, hardness, sulfate, chloride, alkalinity, nitrite, nitrate, sodium, and potassium.
II	(water, heavy metals) iron, manganese, chromium, copper, aluminum, cadmium, zinc, and lead.
III	(water, fluorides) fluorides, with and without distillation, in the presence and absence of added interferences using a specified procedure and comparing it with the method of choice, preferably the routine method employed by the individual laboratory.
IV	(air, inorganics) examination of both glass fiber filters and a liquid extract containing sulfate, chloride, nitrate, and fluoride.
V	(water, radiological) preliminary evaporation and counting of a liquid sample for gross beta activity.
VI	(water, surfactant) alkyl benzine sulfonate in distilled water, tap water, and river water.
VII	(water insecticide)*

* Not yet announced as available for study.

Magnesium

Both calcium and magnesium were formerly determined by gravimetric procedures, the total of the two being reported as hardness. Since the advent of EDTA procedures for calcium and hardness, magnesium is commonly determined as the difference between the two, with a substantial saving in time.

The calculated magnesium results based on twelve reports had a standard deviation of 5.4 mg/l. For the actual manipulative procedures (EDTA titration, gravimetric, colorimetric, flame, and lime water) the average deviation was only 1.6 mg/l. Small errors in the calcium and hardness measurements are reflected and magnified in the calculation of results, which accounts for the larger deviation.

Hardness

The hardness determination is of great interest in this study, if only from a historical viewpoint. In a short space of about 10 years, the old, tedious soap titration has been completely supplanted by the EDTA titration. All 31 of the cooperating laboratories used the EDTA reagent in the I-A study, and 19 of 20 used the same procedure in the earlier, Type I study.

From a concentration of 608 mg/l as $CaCO_3$, 31 groups had a standard deviation of 13.7 mg/l. The only points of difference were the choices of indicators and buffers. Half of the groups reported results within 2 per cent of the true amount.

Sulfate and Chloride

Sulfate and chloride ions present little difficulty to water chemists, as is shown by the results. On both Type I and I-A samples all laboratories obtained results very close to the true values.

For sulfate procedures most laboratories use the dependable gravimetric method, while a few use the turbidimetric technique. From a concentration of 288 mg/l, 22 laboratories had a standard deviation of 9.2 mg/l using

the gravimetric method, and 11 groups using the turbidimetric method had a standard deviation of 32.1 mg/l. Obviously, because the simplicity and speed of the latter technique are offset by its lack of accuracy, individual laboratories should evaluate their accuracy requirements before choosing one of these methods for a routine procedure.

For the chloride measurement (219 mg/l), the Mohr and the mercuric nitrate methods are most widely used. Twenty-three groups reported results based on the Mohr technique and six used the mercuric nitrate titration (Fig. 1). Standard deviations for the two methods, in the order named, were 6.2 and 4.5 mg/l, respectively. This indicates a slight superiority of the mercuric nitrate method, which might therefore deserve more extensive application.

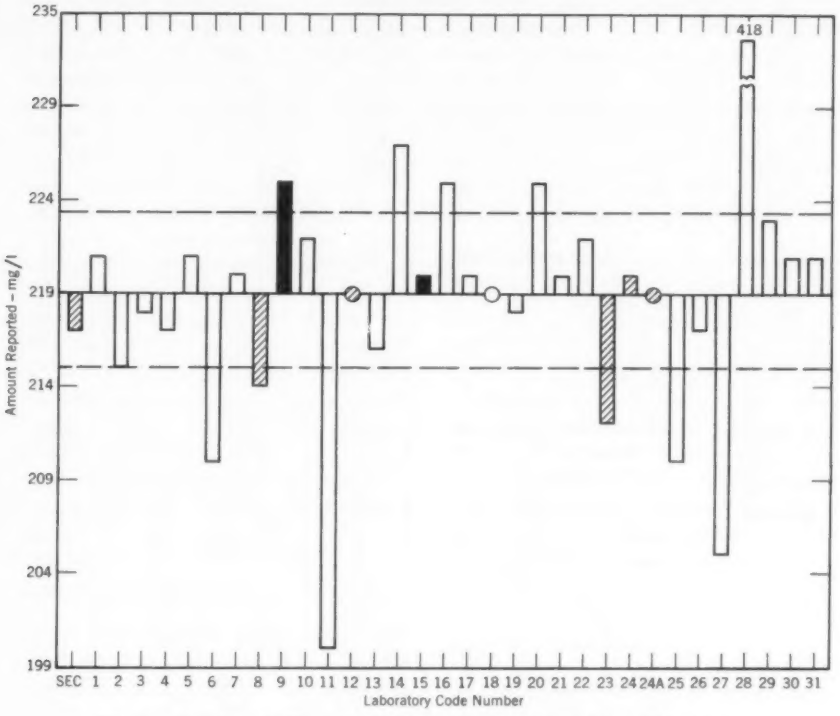

Fig. 1. Results of Three Test Methods for Determining Chlorides

The chloride concentration of the sample was 219 mg/l. Dotted lines represent the standard deviation in the reported results. Each bar represents data from a different laboratory. The first bar (SEC) represents results at the Robert A. Taft Sanitary Engineering Center. White bars—Mohr method; cross-hatched—mercuric nitrate; solid—other.

Alkalinity

When the Type I sample was analyzed for alkalinity, four of 21 members obtained excellent results based on electrometric end points, whereas the results at laboratories using the methyl orange end point indicated a lack of precision. With the distribution of the Type I-A sample the laboratories were requested to compare their usual methods with an electrometric end point if possible.

Of the 31 members performing the alkalinity measurement on the I-A sample, eight groups used two or more methods in reporting the results. The procedures varied only in the choice of indicator or pH for determining the end point of the titration. The indicators included methyl orange, methyl

TABLE 3

Results of Tests on Sample Type IA

Determination	Method	No. of Laboratories Reporting	Amount Added *mg/l*	Avg of Amounts Observed	Standard Deviation	
					mg/l	*per cent*
Calcium	all methods	33	120	119	5.5	4.8
	EDTA	20		120	4.2	3.5
	permanganate	5		121	2.1	1.8
Magnesium	all methods	32	75	76	2.7	3.6
	EDTA	9		75	3.0	4.0
	gravimetric	6		76	1.6	2.1
	calculated	12		77	5.4	7.2
Hardness	all methods	34	608	614	13.7	2.3
	EDTA	31		614	13.7	2.3
Alkalinity	all methods	41	17.0	19.9	3.4	20
	electrometric	18		18.8	3.2	19
	methyl orange	12		21.0	5.9	35
Chloride	all methods	31	219	218	4.1	1.9
	Mohr	23		218	6.2	2.8
	mercuric nitrate	6		216	4.5	2.0
Sulfate	all methods	38	288	283	10.1	3.5
	gravimetric	21		286	9.2	3.2
	turbidimetric	11		266	32.1	11.1
Nitrite	diazotization*	29	0.20	0.19	.041	20
	all methods	33	1.3	1.06	0.41	32
	PDA	27		1.04	0.41	32
	reduction	3		0.9		
	brucine	2		1.2		
Sodium	flame	24	8	9.6	1.3	16
Potassium	flame	23	3.6	3.6	0.36	10

* Only method used.

purple, bromcresol green, bromthymol blue, and a mixed indicator of bromcresol green and methyl red.

Methyl orange predominated as the choice of colored indicator, but is apparently not satisfactory on the basis of the results submitted. At a concentration of 17 mg/l as $CaCO_3$, the standard deviation was 5.9 mg/l. The most obvious weakness with methyl orange is the subjective human error apparently caused by inability of the individual analyst to detect the subtle color changes.

Eighteen members reported alkalinity based on electrometric end points, but the end points used varied from pH 5.1 to 3.9. In general, the results improved as the end point approached pH 4.5. Taken as a single method, regardless of the pH chosen, the electrometric technique showed a standard deviation of 3.2 mg/l for the eighteen laboratories. Obviously, substitution of an objective, physical end point for a subjective one reduces the potential error.

Sodium and Potassium

For sodium and potassium determinations, the flame technique is the only convenient method available; in fact, the cooperating laboratories were requested to use only the flame procedure.

Inspection of the data from 24 laboratories indicates that of the two determinations sodium measurement is the more difficult to perform accurately. A much greater chance for sodium contamination of the sample may account for the greater deviations in the sodium data. Actually it appears that both sodium and potassium can be measured easily without special buffering techniques, provided contamination by extraneous sodium and potassium is avoided (Table 3).

Conclusion

Results obtained in the analysis of Sample Type I-A indicate that, in contrast to the determination of alkalinity, those of calcium, magnesium, hardness, sulfate, chloride, sodium, and potassium can be performed with a high degree of accuracy. The superiority shown by the EDTA methods for hardness, calcium, and magnesium and of the mercuric nitrate method for chloride was noted. A limited number of copies of the detailed reports on Sample Type I-A are available upon request.

Subsequent articles in the JOURNAL will cover the studies of the samples listed in Table 2.

Influence of Basic Fuchsin and Sodium Sulfite on EHC Endo Membrane Filter Medium

Ralph E. Noble and Marvin Reitman

A contribution to the Journal by Ralph E. Noble, Bacteriologist IV, and Marvin Reitman, Bacteriologist III, South District Filtration Plant, Dept. of Water and Sewers, Chicago, Ill.

THE following approach and procedures from one of the studies in a research and development project now in progress at the Chicago South District Filtration Plant are presented to assist other microbiologists in obtaining valid, objective answers to certain questions of laboratory method. The general program was undertaken because the time of flow of water through the filtration plant is 7 hr, and, in view of this flow rate, a rapid method of determining the coliform-organism content of a water sample is required. National disasters and limited emergencies capable of destroying or inactivating portions of a water distribution system are an ever-present public health hazard and create a further necessity for such methods.

The works of Goetz and Tsuneishi (*1*), Clark and Kabler (*2*), Jeter, Geldreich and Clark (*3*), Hajna and Damon (*4*), and McCarthy (*5*), have stimulated much interest in the membrane filter methods of bacteriological analysis as a means of reducing the time required to determine the coliform bacterial content of a water sample. The compact filter equipment used is portable to the scene of a disaster, makes possible the concentration of coliform organisms from large volumes of water upon a relatively small filter, and requires relatively little space for incubating the bacteriological test filters. The actual incubation time for recognizable colonies of coliform bacteria with this equipment is 18–20 hr, as compared to the 48–96 hr required by the standard procedure.

The tenth edition of *Standard Methods* (*6*) describes a membrane filter procedure using the Environmental Health Center (EHC) Endo medium and recommended it as a tentative method. Such tentative methods are included to encourage as many laboratories as possible to make a careful evaluation of the advantages and disadvantages of the tentative method, in comparison with the currently standard MPN procedure, under a wide variety of geographical and testing conditions. Such evaluation provides information on the usefulness of the procedure. It also encourages the study of specific problems, which may improve the reliability of the method.

Need for Rapid Test

When used properly, the membrane filter technique may provide evidence of heavy coliform-organism pollution in a relatively short time, and may serve a useful purpose in emergencies.

Many water supplies examined for their potability are, however, classified as marginal. In these marginal supplies with low coliform-bacteria density, technically nonpotable water may be approved as satisfactory for drinking purposes by a negative MPN resulting from random sampling variation. Any microbial bias, or mechanical bias, which reduces the MPN estimate below the true value, increases this risk still further. Therefore any new technique proposed for estimating the bacterial population in a water supply should not indicate less pollution than would the standard procedure.

In practice, MPN determinations of coliform bacterial densities in marginal water supplies are subject to several interpretations. As an example, an MPN of 1.8 per 100 ml is the lowest MPN obtainable with a standard five-bank, four-dilution series of fermentation tubes, and an MPN of 1.8 will reject a water supply as technically nonpotable. In practice, locally, two different conditions are recognized. First, when a chlorinated supply is sampled as required according to size of population, and MPNs are derived daily, an occasional MPN of 1.8 is disregarded from the standpoint of water safety control. If three tubes from a single sample are positive, giving an MPN of 7.8, it is immediately assumed the water quality is unsatisfactory and remedial steps are taken promptly. Second, when an untreated supply, such as well water, is sampled and an MPN of 1.8 obtained, the supply does not meet the federal standard for safe drinking water. Resampling, or appropriate treatment followed by resampling, is recommended.

One of the major causes of biased estimates of the coliform-organism population is found in the fundamentals of bacteriological testing. By definition, only bacteria capable of reproducing to form visible colonies on solid media, or of providing other evidence of growth in liquid media, are considered viable. The estimate of the number of bacteria in a sample tested is based on the number of cells capable of developing under the conditions provided—that is, a sample may contain a large number of bacterial cells which remain quiescent in a test medium, but which would multiply rapidly under other conditions, or in other media. Thus, there are many possible criteria of water quality, each depending on the composition of the medium and the incubation conditions under which these organisms are expected to develop.

It is unlikely that either the multitude fermentation test or plate count techniques will show more bacterial cells than are actually present. Any difference between actual and observed population densities is expected to be in the direction of a lower observed density. This factor is relatively unimportant in heavily polluted waters but becomes critical in marginal water supplies. Hence, maximum productivity of the test medium is required to reduce the risk of negative results from such waters.

Media

Strongly selective media are used for the isolation of coliform bacteria. These media are designed to provide conditions under which the coliform organisms will develop readily, and conditions unfavorable for the growth of noncoliform organisms. Two general principles are followed in the de-

velopment of such selective media. The first is that coliform bacteria ferment lactose and produce acid and gas, whereas most other bacteria in water do not. The second fundamental approach, used to intensify the results obtained by means of the lactose in the medium, is the addition of specific inhibitory agents to the medium. Some of these inhibitors are bile salts, brilliant green dye, formate ricinoleate, basic fuchsin, and other compounds. These are intended to inhibit non-coliform-bacteria types that are capable of fermenting lactose, and at the same time, to permit the coliform organisms to develop in the medium. Some of these bacterial inhibitory agents, however, do have some effect on the development of coliform bacteria, permitting only the stronger, more vigorous cells to develop and form visible colonies, or to show evidence of growth in liquid media.

The EHC Endo medium described in *Standard Methods* (*6*) includes basic fuchsin, sodium sulfite (Na_2SO_3), and ethyl alcohol to facilitate the cultural identification of coliform types. Ritter (*7*) showed in 1940 that the presence of basic fuchsins in concentrations ranging from 1:5,000 to 1:25,000 definitely inhibited the growth of *Esch. coli* and *Aer. aerogenes* in a peptone lactose broth medium. The concentration of basic fuchsin used in the EHC medium is approximately 1:1,500, or approximately three times the maximum concentration reported by Ritter. An obvious consequence of such inhibitory action is the risk of obtaining lower counts of the coliform bacteria, thus erroneously indicating that a contaminated marginal water supply is relatively free of pollution.

The ingredients of selective media influence both the number of coliform bacteria developing and the rate at which they develop. Therefore, the effect of these ingredients on the estimated number of coliform organisms in the water sample must be studied carefully. This information is required whenever a new medium or set of growing conditions is proposed as an alternative method of estimating the sanitary quality of a water supply. As the productivity of the present standard lactose broth medium has rarely been exceeded, new media frequently result in underestimation of the true coliform population. This underestimation constitutes a public health hazard in the evaluation of the sanitary quality of marginal water supplies. Further, any ingredient in a medium shown to reduce the productivity of that medium may also reduce the rate of growth of coliform bacteria. This characteristic makes such an ingredient undesirable for inclusion in further studies in the development of any medium designed to provide an estimate of the coliform population in a time approaching the 7-hr period required for processing water through a large filtration plant. The membrane filter technique may, however, serve as a vital intermediate step toward the development of a reliable rapid test for coliform organisms in this short a period.

The general approach to the problem and some of the reasons for the emphasis on productivity of media have been presented. The procedures described have a wide general application in productivity studies and in comparisons of different bacteriological tests.

Nature of Experiments

This investigation was made to study the influence of the concentrations of basic fuchsin and sodium sulfite used

in the EHC basal medium, on the productivity of the EHC medium specified in *Standard Methods* for use in the membrane filter technique.*

The experimental design for this study was selected to give the closest possible comparison of the productivity of EHC medium with and without the basic fuchsin and sodium sulfite. Four different membrane filters were inoculated with aliquots of the same bacterial suspension. Each was incubated 2 hr on a pad of EHC enrichment medium at 35°C. Two of the filters were then incubated with the complete EHC Endo medium and the remaining two filters were incubated on EHC Endo medium not containing the basic fuchsin and sodium sulfite for 18–20 hr at 35°C. Thus, any marked differences could be attributed to the media rather than to the bacterial suspension. Duplicate filters were used because the average of duplicates provides a better estimate of the number of bacteria capable of developing under the conditions provided than could be obtained from a single filter. This test unit was replicated 65 times from Oct. 23, 1956 to Mar. 21, 1957. Thus any conclusions drawn from these data are not limited to a single bacterial suspension or to laboratory conditions prevailing for a few days. In each of the 65 replications, an *Esch. coli* suspension was given four membrane filter counts —A_1 and A_2 with fuchsin and sodium sulfite present, B_1 and B_2 with them absent. Two membrane filtering units were used in the inoculation of the test filters in each replication—that is, A_1, A_2, B_1 and B_2. It was necessary to eliminate the possibility that a pair of unusual filter counts on the same medium could be attributed to one filter unit, rather than to the medium tested. Therefore, Unit 1 was used to prepare Filters A_1 and B_1 and Unit 2 was used to prepare Filters A_2 and B_2.

* Other formulas for the membrane filter test for coliform bacteria have not yet been similarly tested in this laboratory to determine the effect of inhibitors on the productivity of a given medium for coliform organisms (*4, 8–10*).

Laboratory Procedure

A pure culture of *Esch. coli* previously isolated from untreated Lake Michigan water, was used as the test organism in this series. The culture had IMViC † reactions of plus, plus, minus, and minus, respectively. Stock suspensions were prepared from time to time and used to facilitate control of the number of colonies concentrated on the filters. The pure culture was streaked on tryptone glucose extract (TGE) agar slants and incubated 24 hr at 35°C. The growth on these agar slants was then suspended in approximately 50 ml of sterile, buffered distilled water. The resulting suspension was stored in the refrigerator at 5–6°C for use as long as the number of viable bacteria in the suspension remained relatively constant. The average of counts of five TGE agar plates prepared from this stock suspension was used to indicate changes in the number of viable cells. An aliquot from a stock suspension was added to a standard, buffered dilution blank to prepare the test suspension for the four filters used in each replicate indicated in the experimental design. The concentration of these working suspensions was varied during the study to insure a range of 5–150 colonies per 100 ml.

† Indole, methyl red, Voges-Proskauer, and citrate tests, respectively.

Each of the four inoculated filters, A_1, A_2, B_1, and B_2, was placed on a filter pad previously inserted in a sterile ointment box and saturated with 2.0 ml of EHC enrichment medium. These were then incubated in the covered ointment boxes for 2 hr at 35°C. At the end of this period, filters A_1 and A_2 were each transferred to a sterile filter pad previously placed in a sterile ointment box and saturated with 2.0 ml of the EHC Endo medium containing the basic fuchsin and sodium sulfite ingredients. Similarly, Filters

TABLE 1

Coliform-Organism Development in Presence or Absence of Basic Fuchsin and Sodium Sulfite, October 1956–March 1957

Date	No. of Colonies*		Date	No. of Colonies*	
	Fuchsin and Na_2SO_3 Present	Fuchsin and Na_2SO_3 Absent		Fuchsin and Na_2SO_3 Present	Fuchsin and Na_2SO_3 Absent
October 23	48.5	43.0	February 18	22.5	40.0
23	50.5	71.0	26	30.5	36.0
24	25.0	41.0	26	23.5	22.5
24	46.5	68.0	27	23.0	18.0
25	42.5	57.5	27	35.0	35.5
26	41.0	81.5	27	36.5	56.0
26	42.5	89.0	28	13.5	23.5
30	51.5	80.5	28	35.5	49.0
30	68.5	93.5	28	85.0	101.5
31	86.0	97.5			
31	115.5	123.0	March 1	28.0	36.5
			1	55.0	68.5
November 1	63.0	65.5	1	69.5	73.5
1	72.0	95.5	4	21.5	31.0
2	48.0	57.5	4	41.0	62.5
2	50.0	64.0	4	78.0	107.5
			5	68.5	96.0
January 21	34.0	47.5			
22	24.5	46.0	5	104.0	135.5
22	37.0	39.0	5	101.5	124.5
22	63.5	64.5	6	105.5	129.5
23	4.0	6.5	6	105.5	126.0
23	19.0	17.0	6	113.5	128.0
23	108.0	110.5	6	143.0	144.0
24	30.0	43.0	6	130.0	153.5
24	43.5	79.0	6	126.0	132.5
29	11.5	6.0	20	87.0	114.0
29	16.5	18.5	20	105.5	139.0
29	74.5	104.5	20	102.0	139.0
30	60.5	96.0	20	119.5	149.5
30	12.5	13.0	21	82.5	83.5
			21	79.0	98.5
February 13	4.0	8.5	21	65.0	89.5
13	10.0	12.5	21	108.5	112.0
18	29.0	51.0	21	110.0	124.5

* Average of two replicates.

B_1 and B_2 were each transferred to pads that had been previously saturated with EHC Endo medium from which basic fuchsin and sodium sulfite were withheld. The covers were replaced and the filters incubated 20 hr at 35°C. After incubation, approximately 0.5 ml of 1 per cent triphenyl tetrazolium chloride was added to each filter incubated on the EHC Endo medium that did not contain basic fuchsin and sodium sulfite, to color the colonies and facilitate counting.

Data

The data consisted of four membrane filter counts from each of the 65 replicate units. The pair of counts from Filters A_1 and A_2 were averaged to estimate the number of *Esch. coli* in the working suspension that were capable of developing on EHC Endo medium containing basic fuchsin and sodium sulfite. Similarly, the corresponding counts from Filters B_1 and B_2 were averaged to estimate the number of cells, from the same working suspension, that were capable of developing on EHC Endo medium that did not contain basic fuchsin or sodium sulfite. These data are shown in Table 1.

For convenience in comparing the two series of averages in Table 1, these data are plotted in the regression diagram shown in Fig. 1. As the number of colonies developed on each medium was not influenced by the composition of the other medium, it was necessary to designate arbitrarily one series of data as the independent series and leave the other as the dependent series. This decision was based on the fact that the EHC Endo medium containing basic fuchsin and sodium sulfite is the medium described in the tentative procedure published in the tenth edition of *Standard Methods*. Therefore, the average of the pair of counts from filters incubated on this medium was considered the independent variable and was measured on the ordinate axis. The average of counts from the corresponding pair of filters incubated on the modified EHC Endo medium lacking the basic fuchsin and sodium sulfite was measured on the abscissa. Thus, one point was obtained from the data for each of the 65 replications in this study, as shown in Fig. 1.

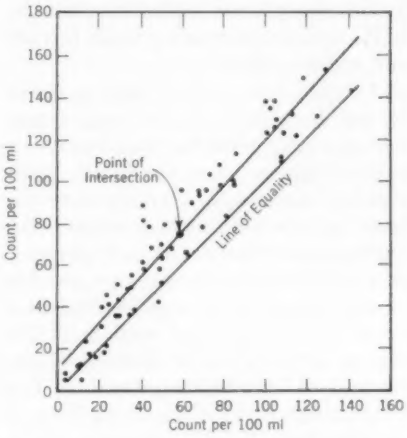

Fig. 1. Comparative Coliform-Organism Counts in Presence and Absence of Basic Fuchsin and Sodium Sulfite

The modified and unmodified EHC Endo medium counts are plotted along the vertical and horizontal axes, respectively. The graph shows consistently higher counts for the modified EHC Endo medium (basic fuchsin and sodium sulfite absent). This indicates that the unmodified medium exerts an inhibitory action on the growth of coliform organisms.

All points shown in Fig. 1 are expected to fall on the line of equality,

provided that: [1] the two media are equally productive—that is, the basic fuchsin and sodium sulfite have no effect on the bacteria other than to facilitate identification of the coliform bacterial colonies; and [2] there is no sampling variation in the filter data. Contrary to this expectation, 60 of the 65 points fell above the line of equality, indicating that the modified EHC Endo medium was more productive than the EHC medium containing basic fuchsin and sodium sulfite.

An examination of the data in Table 1 and in Fig. 1 shows consistently higher averages for bacterial counts on pairs of filters when the EHC Endo medium was modified to eliminate the basic fuchsin and sodium sulfite. By averaging all the data for each medium, it was found that the average number of colonies per filter was 74.9 for Medium A (fuchsin and sodium sulfite absent) and 59.8 for Medium B (fuchsin and sodium sulfite present). The productivity of EHC Endo Medium A is, therefore, 125.25 per cent of the productivity of Medium B. This constitutes evidence of the inhibitory qualities of the basic fuchsin and sodium sulfite present to facilitate identification of coliform colonies developing on the EHC Endo medium described for use with the membrane filter technique in *Standard Methods*.

A straight-line regression was fitted to these data, using the method of least squares. This line was used to describe the general relationship between the number of colonies of *Esch. coli* developing on membrane filters both when basic fuchsin and sodium sulfite were present in the EHC Endo medium and when basic fuchsin and sodium sulfite were omitted from the medium. The method of least squares places this line in such a position that it passes through the average of both sets of data (59.8, 74.9) and the sum of squares of the deviations from this line are a minimum. The estimated count per 100 ml when basic fuchsin and sodium sulfite are omitted is 9.4117 plus 1.0957 times the count per 100 ml obtained with both basic fuchsin and sodium sulfite in the EHC Endo medium. It should be noted that this line does not cross the line of equality and remains roughly parallel to it, as shown in Fig. 1. This is further evidence of the inhibitory action of basic fuchsin and sodium sulfite on the pure culture of *Esch. coli* used in this investigation.

Conclusions

These data provided conclusive evidence that basic fuchsin and sodium sulfite in the EHC Endo medium prevented the development of a proportion of the bacteria in the working suspension of the pure culture of *Esch. coli* used to inoculate membrane filters in this study. This inhibitory action yielded an underestimation of the number of coliform organisms that would otherwise have been capable of developing on that medium. The EHC Endo medium, described in *Standard Methods* for use with the membrane filter method of bacteriological analysis of water samples, was arbitrarily given a productivity rating of 100 per cent. The productivity of the medium rose to 125 per cent when basic fuchsin and sodium sulfite were omitted. The number of coliform bacterial colonies developing on each membrane filter and incubated on EHC Endo medium containing basic fuchsin and sodium sulfite averaged 59.8 colonies, which represents 100 per cent productivity. The corresponding average was 74.9 colonies per membrane filter incubated

on an EHC Endo medium that did not contain basic fuchsin and sodium sulfite. These averages were used to calculate the relative productivity of the two media.

Further evidence of the inhibitory action of basic fuchsin and sodium sulfite was provided by the regression line used to estimate the number of *Esch. coli* colonies developing on the modified EHC Endo medium from the number obtained when EHC Endo medium containing basic fuchsin and sodium sulfite was used. This line remained consistently above the line of equality. Therefore, there was little possibility of establishing a range of colonies developing on the membrane filters in which interchangeable estimates of the coliform population can be obtained from either of these two formulas for EHC Endo media.

The compounds tested in this investigation are only two of the many possible ingredients in selective media for coliform isolation and identification. Many other ingredients should also be examined in an effort to obtain maximum productivity of these media. This will reduce the public health hazards associated with any microbial bias likely to produce a lower estimate of the pollution in a marginal water supply than would be obtained from the currently standard MPN procedure.

Modern experimental designs and statistical techniques provide many objective and efficient methods of conducting these necessary evaluations of bacteriological media. Fundamentally, the criteria for the bacteriological quality of a public water supply are based upon the number of coliform bacteria developing under the conditions provided. Therefore, the accuracy and precision (reproducibility) of estimates of pollution based on each new criterion must be evaluated objectively. These new procedures must be carefully calibrated in relation to the current lactose broth, decimal dilution procedure for estimating the most probable number of coliform bacteria in the water sample tested.

Traditionally, bacteriological test data are historical in nature. The finished water leaves a filtration plant many hours before the bacteriological determinations are completed. The accumulation of information regarding the productivity, accuracy, and precision of new bacteriological methods of water analysis, however, plus the development of modern laboratory equipment, including the electron microscope, are expected to reduce the time necessary to obtain reliable information regarding the sanitary quality of water processed in a large filtration plant. The 7-hr period required at this plant to process the water makes it urgent that increasingly reliable and more rapid bacteriological-analysis procedures be found.

Acknowledgment

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Susquehanna Project for Baltimore

Bernard L. Werner

A paper presented on Oct. 30, 1958, at the Chesapeake Section Meeting, Wilmington, Del., by Bernard L. Werner, City Water Engr., Baltimore, Md.

THE original water supply of almost every large community in America is procured only for the benefit of the citizens within that community. As the village or city grows in size, however, areas beyond the boundaries are developed for residences and large industries. Water is needed in these areas and the city water system and other utilities have to serve them. This is the natural pattern of development of a community water system.

A city having an organized government usually procures a source of water supply of a size larger than is essential for its immediate needs. The people outside the city boundaries then buy water delivered to them, and from that point on the city continues to make plans for increasing the water supply to meet the growing demands of the area. In extending its water system, the city almost invariably preempts water sources beyond its boundaries, thus leaving few sources available for the suburban areas. It is therefore the responsibility of the municipality to provide an adequate water supply to these areas.

Baltimore's Growing Demand

In January 1952, when the population in the neighboring counties began to expand quite rapidly, Baltimore decided it was time to anticipate the growth of its water demands for the year 2000. A board of advisory engineers was appointed to determine these needs and to recommend a new source of water supply.

The board, with Abel Wolman as its chairman and Gustav J. Requardt and Harry B. Shaw as the two other outside members, together with the director of public works and the author, reported its findings on Dec. 15, 1953. It was the opinion of the board that the Baltimore water system would have to supply 460 mgd to 2,200,000 persons in the city and its four neighboring counties, Baltimore, Howard, Anne Arundel, and Harford.

There was a reevaluation of the existing sources of raw water, Gunpowder Falls and the north branch of the Patapsco River, and it was determined that the safe yield from those two streams was 243 mgd, a figure that had been previously ascertained when it was decided to tap the Patapsco for the second source of supply.

It was obvious that the city would need a third source of raw water, and the board estimated that the new source should be available by 1962, that being the year when the average daily demand will exceed the safe yield of the present sources of supply. Every major source of raw water within a 50-mi radius of Baltimore was studied. These included the Potomac, Patuxent, Monocacy, Little

Gunpowder, and Susquehanna Rivers and Deer Creek. The Susquehanna River was selected.

Susquehanna Project

The Susquehanna River at Conowingo, 4 mi north of Havre de Grace, has large quantities of available water. The length of the river is nearly 450 mi, and it drains an area of 27,510 sq mi, of which 20,465 sq mi lies in Pennsylvania, 5,263 sq mi in New York, and 282 sq mi in Maryland. Its physical, chemical, and bacteriological characteristics are good; its single drawback, aside from its distance from the area of service, is that all of the water must be pumped, because of the low elevation of the river at Conowingo. The water can, however, be pumped at a relatively low cost.

The board recommended that a 108-in. pipeline be installed from the proposed Susquehanna River intake to the Montebello filtration plants. The route of this pipeline was planned so as to parallel US Highway 40 and the Baltimore and Ohio Railroad through the undeveloped tidewater area between Aberdeen and Baltimore, which is expected to become heavily populated and industrialized.

Water from the Patapsco River and Gunpowder Falls flows by gravity into the Ashburton and Montebello filtration plants, respectively, pumping being required only when low reservoir levels prevail. The average runoff from these watersheds is 386 mgd. Owing to topographic and economic limitations, it is not feasible to construct further impoundments to hold all of the water that these two watersheds can produce. As mentioned before, the safe yield of these watersheds with the existing dams is 243 mgd; therefore, on the average, 143 mgd flows over the spillway and is lost. The advisory engineers recognized this condition and planned the Susquehanna initially as a supplemental supply to be used only when the gravity sources could not provide the required flow. Upon completion of the Susquehanna project, it will be possible, under average conditions, to obtain drafts in excess of the safe yield from the Patapsco and Gunpowder supplies by lowering the reservoir levels below those presently maintained. Water from the Susquehanna will be pumped to augment the gravity flow. By this method of operation, called "firming" by the advisory engineers, less water will be wasted over the dams and more will be available from the Gunpowder and Patapsco supplies.

In the 1955 session of the Maryland legislature the city introduced enabling legislation, senate bill No. 30, which, in effect, gave the city the right to take water from the Susquehanna River above Conowingo Dam and to acquire rights-of-way in Harford and Baltimore counties for the building of pipelines and structures necessary to bring the supply to the city. The legislature also provided that up to 10 mgd should be made available to Harford County at four separate points along the pipeline. Senate bill No. 26 provided for a $45,000,000 loan to enlarge the water system, subject to a referendum held in the general election in the fall of 1956. These bills were approved by the legislature and signed by the governor, and the loan was passed by the voters. Subsequently, the Bureau of Water Supply proceeded with the engineering phase of the work and engaged a firm of consultants.

Project Plans

On Oct. 3, 1956, the consulting engineers presented their preliminary layout report to the bureau. They recommended an intake structure above the Conowingo Dam, a tunnel around the dam, a pipeline along the Susquehanna River Canal to Deer Creek, a pumping station of 250-mgd capacity at Deer Creek, and a pipeline, approximately 35 mi in length, from the pumping station to the Montebello Filtration Plant.

The report was approved by the bureau, and subsequently detailed field surveys, engineering studies, and right-of-way acquisitions were initiated by the city and the consulting engineers.

Although it is not possible in the space allotted to discuss all of the aspects of the project, features of the undertaking will be described. To begin with, the total estimated cost of the entire project, based on the preliminary report, is approximately $35,000,000. The project is scheduled to be completed in 1962.

Beginning at the Susquehanna River, water will flow through an intake structure which will be located approximately 1,100 ft north of the Conowingo Dam. The intake will be of reinforced concrete, having a length of 47 ft, a width of 57 ft, and a height of 57 ft. About 6½ ft of the structure will be above the average pool elevation so that the deck of the intake will be above the flood waters of the Susquehanna. The face of the intake will be about 100 ft from shore. Counterfort retaining walls will be constructed at a 45-deg angle from the structure to the shore line as an aid in keeping floating debris moving along downstream.

Four separate intake units will be included in the structure. Each unit will have a capacity of 125 mgd. The total capacity, therefore, will be 500 mgd, which is twice the design flow of the pipeline to Baltimore. Additional capacity beyond the predicted flows has been provided because the intake structure involves expensive cofferdam construction, which will not have to be repeated if the future demands should exceed present estimates. It will not be necessary to equip fully the intake units that will be used in the future. When placed in service, each unit will contain vertical bar screens, sluice gates, and a traveling water screen with the necessary stop-log grooves.

The vertical bar screens will consist of 1-in. diameter bars, 4 in. on center. They will be cleaned by an electrically driven, manually controlled trash rake. The stop logs will be used to provide a positive water cutoff if repairs are required on the sluice gates. In each intake unit an 8-ft square sluice gate will be installed on either side of the traveling screens to provide a positive cutoff if repairs are required on the screens. The traveling water screens will remove solids larger than ⅜-in. As the screens rotate, they will be cleaned with spray water. A pumping pit will be constructed over the outlet end of the intake chamber to provide suction for vertical turbine pumps which will supply spray water for the traveling screens and raw water for the pressure filters.

From the intake structure the water will flow through a 12-ft diameter tunnel to a point approximately 1,100 ft south of the dam. The tunnel is required to provide gravity flow through the high ground around the dam. In

order to prevent damage to the power plant at Conowingo Dam, the tunnel alignment will be at least 500 ft from the end of the dam. The 12-ft tunnel will be able to discharge 500 mgd, the same flow as the intake structure. This will eliminate the necessity of re-entering the Susquehanna in the proximity of the dam in the future. From the south portal of the tunnel the water will flow by gravity through a 108-in. pipeline to Deer Creek. The pipeline will parallel the Conowingo Power Co. railroad by about 35 ft.

Deer Creek Pump Station

At Deer Creek a 250-mgd pumping station will be built to pump the water to the Montebello Filtration Plant. The site for the station was dictated by the terrain because the pumps must be located below the hydraulic gradient at design flow from Conowingo in order to obtain a positive suction head. The pumps could not be installed above an elevation of 66 ft. Any facilities below elevation 32 ft, however, would be in the flood plain of Deer Creek. Fortunately there are a couple of sites available at the proper elevation on the southwest side of Deer Creek.

The flow of water into the city from the pumping station may vary from 6 to 106 mgd in 1975 and from 163 to 233 mgd in the year 2000, depending on whether the Susquehanna is used to "firm up" the gravity sources. The wide range of flows and heads is beyond the limits of any single-speed pump. As a solution to this problem, the consulting engineers recommended that five pumps be installed in the station, three of which would be equipped with couplings for motors at each end. These three pumps could be operated by a low-speed motor on one end for low-head conditions and a high-speed motor on the other end for high-head conditions. The other two pumps would have one motor for high-head conditions. Initially, only three 50-mgd pumps with low-speed motors will be installed.

Side suction pumps will be used to keep all piping and valves at the pump level. Steel piping and steel-bodied valves will be used in the station. Butterfly valves will be placed on both sides of each pump to permit isolation of the pump for repairs without shutting down the station. A cone valve will be placed on the discharge side of each pump to provide controlled closing against pressure surges. All valves will be hydraulically operated and an accumulator system will be provided to ensure valve closure in the event of a power failure. The pipes and butterfly valves will be 36 in. in diameter and the pumps and cone valves will be 30 in. in diameter, or the same size as the pumps. Each pump will have an individual flowmeter.

The pumping station substructure will be reinforced concrete. There will be a steel-frame superstructure with a red-brick exterior and a tile interior. There will be two levels in the station—an operating level and a motor level. All of the pumps, piping, and valves will be located on the motor level. The operating level will contain the electrical switchgear, boiler room, office, and control room. From the control room the operators will be able to see the motor room at all times. A schematic diagram of the station piping will be provided in the control room with pushbutton stations installed for valves and motors at the appropriate locations on the diagram. Various meters will be provided to indicate the

flow through each pump, the water levels at Conowingo and Montebello, line pressure, and similar data.

The electrical supply will be one or two overhead 33,000-v lines. A substation will be built to house the transformers and other electrical equipment. An overhead bus duct will transmit power to the indoor switchgear and auxiliary transformer.

A macadamized road will be built to the station to provide access. Parking and loading zones will be constructed adjacent to the plant.

Pipelines to Montebello

When the water leaves the Deer Creek Pumping Station it will flow through a 108-in. pipeline to Fullerton in Baltimore County. From Fullerton Susquehanna water will flow through a 96-in. pipeline to the Montebello Filtration Plant.

The pipeline size has been reduced because the city plans to build a reservoir and filter plant at Fullerton in 1975. The plant will treat 160 mgd from the Susquehanna. When the draft exceeds 160 mgd, the excess will flow through the 96-in. line to the Montebello Filtration Plant. Although this project is planned for the future and is not part of the Susquehanna work, the city is now acquiring the necessary property at Fullerton for these additions to the system. Also, the city is making certain provisions in the Susquehanna project to facilitate future construction at Fullerton.

A tunnel will be constructed in Baltimore County and one in Harford County as part of the pump line. These tunnels are required in order to place the line under high ground, thereby avoiding excessive pumping heads at Deer Creek. The tunnel in Harford County will be about 13,000 ft long, and the one in Baltimore County will be about 1,100 ft long. Both tunnels will have reinforced-concrete linings, poured monolithically, to withstand maximum hydrostatic pressure in excess of overburden pressure.

An analysis was made of the fluctuation in pressure in the pipeline owing to water hammer. It was determined that the pipeline could be protected by the use of three surge shafts in conjunction with air inlet valves and surge suppressors at several critical points. One surge shaft will be placed on the suction side of the Deer Creek Pumping Station to protect the gravity flow line from excessive water hammer pressures. The section of line between Montebello and the pumping station will be protected from excessive positive and negative surges in head by two shafts, one on the tunnel in Harford County and one at Montebello.

The pipeline in most instances will have 4.0-ft ground cover, although in some places the depth may reach 25 ft at points controlled by the hydraulic gradient. At other points the pipeline was kept deep to permit other utilities to cross over the line. The first section of pipeline let was 30,200 ft in length. Prestressed-concrete, embedded-cylinder pipe was chosen by the contractor, although steel pipe with a $\frac{1}{2}$-in. mortar lining and 1-in. exterior coating was permitted as an alternate. A combination automatic air release and air intake valve will be provided at all peaks along the pipeline, and blowoffs will be placed at every low point on the line. Access manholes will be placed about every 1,500 ft along the line for inspection and maintenance purposes.

Montebello Improvements

With the introduction of Susquehanna water into Montebello, it was necessary to make various improvements in the plant facilities to handle both the Gunpowder and Susquehanna supplies. The improvements consisted of a raw-water distribution center, a surge shaft, electrical-equipment building, a 12-ft tunnel, and other large conduits. The distribution center will contain three 120-mgd, vertical, mixed-flow pumping units, which will be used to pump water from the Gunpowder supply, when necessary. The center will also contain an arrangement of pipes and valves which will allow the Gunpowder and the Susquehanna supplies to be mixed or to remain separate, one supply to each plant. The existing aerator gatehouse at Montebello will be renovated as a surge tower. When certain improvements are made at Loch Raven in addition to those at Montebello, the gravity flow from Loch Raven will be increased from 205 to 300 mgd when that reservoir is full.

The city awarded two contracts in 1958—one for the raw-water distribution center, and one for the raw-water conduit (first section of the 96-in. pipeline from Montebello to Kenwood Avenue). In 1959 the city plans to award contracts for the construction of the Conowingo Intake and Harford County tunnels and the 108-in. pipeline from Winters Run to Conowingo. Construction of the Deer Creek Pumping Station and the raw-water conduit from Kenwood Ave. to Winters Run is scheduled to begin in 1960.

West Virginia's Water Resources

Walter C. Gumbel

A paper presented on Oct. 23, 1958, at the West Virginia Section Meeting, Charleston, W.Va., by Walter C. Gumbel, Conservationist, Monongahela Power Co., Fairmont, W.Va.

IT has been said that the story of water is the story of man. History records the fall of several great civilizations because they neglected to care for the land and the waters. Even today, in such areas as the Middle East where these civilizations flourished, the situation has not improved over what it was centuries ago. Standards of living are low because it requires a constant effort by everyone to produce even the most basic necessities of life in an impoverished land. On the other hand, the average annual rainfall has remained fairly constant in such areas, as it does everywhere. There is, however, one difference: populations have increased and the scant supplies of available water and food must be spread thinner. These conditions have created serious social and political problems for which reasonable solutions must be found. Some of these have international implications and are contributing factors to tension between nations.

Water and the Future

In the United States, a country young in years and rich in natural resources, water is a key factor in the upward surge of the economy. This country, too, is plagued with problems. Some are widespread and others are local in character, but the constant increase in population is the predominant cause of water supply problems. As the great recording clocks tick on in the Department of Commerce in Washington, they record a birth every 8 sec, a death every 21 sec, an immigrant every 2 min, an emigrant every 24 min. When the tally is made at the end of each day, it shows 7,200 new Americans to be fed, clothed, educated, and ultimately employed. The best estimates are that the United States will have more than 235,000,000 citizens by 1975—only 16 years from now. The population reached 175,000,000 people on Oct. 16, 1958. This is just in the United States; the same growth is taking place in most other nations of the world. It means millions of more people to be fed and provided with water. This is the great task that faces the water supply industry today, and and far into the future.

Need for Foresight

The progress of a profession, a society, an organization such as AWWA, or any industry, depends upon what it is doing today and how well it is planning for the future. No group is better qualified to forecast the water and food requirements of the future than those who are dedicated to the development and wise use of our basic renewable natural resources. Such dedicated persons are to be found in all walks of life—on farms, in industry, in gov-

ernment resource agencies, in trade organizations, in the public schools, in colleges and universities, in the sewage and industrial wastes field, and in the 18,000 water utilities scattered throughout the land. The achievements of these people are reflected in the greatness of the nation.

However great progress may have been thus far, there is no justification for resting on laurels. There are more water resource problems lurking on the horizon than ever before. In addition to increases in population, there have been great technological advances in agriculture and in industry. As automation increases and as science opens the way to new discoveries, additional pressures can be expected to be brought to bear on the nation's water resources. Consideration will be given here to the problems and progress of one state, West Virginia.

In recent years, widespread droughts, numerous water shortages, and the rapid increase in the volume of water used by agriculture, industry, municipalities, and recreational interests in West Virginia have created reasons for public concern. These difficulties have raised many questions. How severe are local water shortages? Are they temporary, or are they likely to be permanent? Is the best use being made of water resources? What can the state and its citizens do to help correct these problems? What administrative arrangements are necessary to provide for a sound statewide water resources program? Whatever the answers may be, it is obvious that the future pattern of West Virginia's growth and development will depend upon the wisdom and foresight of resource leaders in developing and allocating water for optimum benefit.

Use and Available Supply

West Virginia has a great abundance of water. This does not mean, however, that the available supply is adequate in all areas of the state. In some sections distribution is a critical problem. Industrial expansion, agricultural development, population growth, and a growing interest in water for recreation are also increasing the demands for water. In some areas, droughts and floods have accentuated the water problem. The discharge of used waters by cities and industries into streams has created a pollution problem that is slowly being corrected through the efforts of the state water commission.

The estimated withdrawal of water in West Virginia for 1955 totaled 4.12 bgd. This placed West Virginia in ninth place among the 31 states east of the Mississippi River in the consumption of water for all uses.

The average rainfall for the state is 43.36 in. This represents a supply of about 19,000 bil gal each year. Of this amount, approximately 50 per cent leaves the state as surface water runoff. This is more than six times as great as the amount of water withdrawn for use in 1955. Runoff occurs during periods of high water or floods. Major ground water recharge is accomplished during periods of rainfall and is usually returned to the stream at a later time. Consequently, the major water use problem in West Virginia is the distribution and quality of water rather than the gross supply.

Increases in Water Use

Water use in the United States has doubled, on the average, about once every 25 years. Agricultural, industrial, and business establishments used

a total of 40 bgd in 1900, or approximately 526 gpcd. By 1955, the total estimated water use exceeded 240 bgd —an increase of 500 per cent. The per capita use amounted to 1,455 gpcd, or a 117 per cent increase.

In 1955, the total amount of water used was about 20 per cent greater than in 1950. Of this amount, about 5 per cent of the total daily per capita consumption was devoted to domestic use. This use varies from 180 gpcd in larger cities to 60 gpcd in small communities with running water, the average being 148 gpcd. The projected per capita use by 1975 is expected to exceed 175 gpcd (*1*).

Recent studies by recognized government commissions further report that if a doubling of water use occurs from 1950 to 1975, as projected, it will result in a total withdrawal of water about equal to the estimated supply available for development under present conditions. This is not necessarily a cause for alarm, especially in West Virginia, where the supply is now six times as large as the use. It does mean, however, that conservation measures must be accelerated, pollution reduced, better techniques of reuse devised, improved patterns of consumption encouraged, and the allocation of water between competitive uses developed.

Trends in West Virginia

Water use trends, although national in scope, are reflected in West Virginia's economy. The state should begin now to plan for its future water needs, in view of the growing population, continued industrial expansion, and the need for water for irrigation, recreational uses, and scenic values.

In this connection, it should be pointed out that the state's estimated population on Jul. 1, 1957 totaled 1,976,000 people, while the projected population for 1975 is expected to reach 2,382,000. This represents an increase of 398,000 persons, or 20.1 per cent. These increases are expected to occur in the larger towns and cities of the state.

As for agriculture, it is clearly obvious that the present trend in irrigation will continue upward with heavy increases in the use of water. A study completed about a year ago by the State Agricultural Experiment Station shows that 56 commercial farms have installed irrigation systems to supply supplementary water on 2,531 acres. More than 50 per cent of these farms are located east of the Allegheny Mountains. The remaining farms are in the lower Greenbrier Valley and in the lower sections of the Ohio River. Agriculture in West Virginia will need to develop vertically rather than horizontally because of the topography and space limitations. Consequently, irrigation appears to be a great potential means of aiding this segment of the state's economy. The question of water rights is a major problem in the irrigation of agricultural lands. This is already apparent in several sections of the state. The problem will not, however, become critical until conflicting water uses create shortages.

Recreational use of resources is another area in which water will play an important role. An increasing population density, fewer working days, and improved standards of living will add to the number of people in search of opportunities to camp, picnic, hunt, fish, or just travel through the state's scenic mountain areas. A survey conducted in 1956 shows that 400,000 of the state's 2,000,000 people either hunted or fished or did both. Already

tourists are spending well over $225,000,000 annually in West Virginia. This is an important development and cannot be ignored in the state economy.

This resume shows that West Virginia is rapidly moving into an era in which water will be a dominant factor in the economy. It already ranks first in many western states and in numerous cities and towns in the East. Water shortages usually affect everyone, and the problem is, therefore, a complex one. Solutions involve the treatment of agricultural lands, water rights, flood protection, abatement of pollution, as well as the financing and construction of new water supply systems. These related factors need to be well understood. There was a time when municipal water facilities were constructed with no relation to other interests. Increased industrial expansion, irrigation, domestic, and related needs have changed the setting. It is now necessary to think in terms of the optimum use of all waters that fall on a common drainage basin or watershed.

People too often fail either to know or to understand the importance and relation of conservation programs to water needs. In this connection, there are three important areas of interest that concern water users in West Virginia: [1] watershed management, [2] water rights, and [3] legislation.

Watershed Management

The conservation movement in this country is less than 30 years old. It started with the application of soil and water conservation measures on farms and ranches. These programs have been highly effective in retarding runoff, conserving soil, and improving the fertility of the land. To date more than 35,000 West Virginia farms, embracing over 5,000,000 acres, have established such programs through their local soil conservation districts. These represent about 50 per cent of all farms and one third of the total land area in the state.

A more recent innovation in conservation has been the small-upstream-watershed program. These areas generally include all the land that drains into a single small stream. Municipalities and industries within or adjacent to a watershed unit are vitally concerned with the maintenance of water tables, local water supply, pollution abatement, and flood control. What happens to water on the land and in the streams determines the availability and quality of water for domestic and industrial needs. Programs designed to help protect the land also protect public water supplies and help prevent floods in the upstream areas of small watersheds.

These programs are generally too big for a single landowner to handle. They need to be dealt with in the watershed as a whole. In fact, they can be better handled by agricultural, urban, industrial, and recreation interests working as a team. It is an important fact that there is a joint responsibility on the part of landowners and persons living off the land.

Typical of this movement in West Virginia is the Salem Pilot Watershed near Clarksburg, which was recently dedicated. The area, although small, has a population of 2,500 and embraces 5,376 acres, including 115 farms. Records show that the average annual flood damage has been $30,615. A devastating flood in 1950, however, caused damages totaling $233,000.

The completed program includes seven flood detention reservoirs and one municipal water supply reservoir.

The capacity of the reservoirs is sufficient to trap a 3-in. rainfall. Except for the city reservoir, each structure has a storage pool through which normal flow passes, and added basin capacity to hold back excessive runoffs. The reservoir, built by the city of Salem to meet growing water shortages, has a capacity of 95 mil gal, of which 46 mil gal is for flood storage purposes.

Conservation and management practices established on the land include the planting of 575 acres in trees, construction of 22 farm ponds, protecting and improving more than 1,200 acres of woodland, liming and fertilizing 1,000 acres of pasture land, and the establishment of 250 acres of contour strips. This represents 75 per cent of the total planned program.

The estimated cost of the project is $410,788. Half of this amount was provided by the federal government while the remainder came from local and state sources.

There are four additional West Virginia watershed projects in the construction stage. They are: South Fork, Hardy and Pendleton Counties and Highland County, Virginia; Warm Springs Run, Morgan County; Upper Grave Creek, Marshall County; New Creek–White's Run, Mineral County; and Dave's Fork–Christian's Fork, Mercer County. Five others are in the planning stage and five are in the application stage. Recent studies show that there are more than 600 small upstream watershed areas in West Virginia. Each represents a community of interest and is generally in need of development. It can readily be seen that the task ahead is big and can only be accomplished through the combined efforts of both rural and urban groups working as a team.

Water Rights

Whether West Virginia will enact a system of clearly defined water rights depends upon how deeply entrenched the riparian doctrine is and the extent to which existing water uses are based upon it. The fact remains, however, that with the rising water needs of towns and cities, agriculture, industry, and recreation, the issue is becoming real. The question of water rights cannot be answered in simple terms. The basic riparian concepts under which the state now operates came from the civil laws of France and the common law of England. Conditions have changed during the years, and the problem must be given careful consideration now, before water users are actually faced with emergencies. One might keep in mind the statement recently made by Abel Wolman of Johns Hopkins University: "No water law creates water; it merely serves to guide the use and development of the resource."

Trends in water use and development have been carefully evaluated in West Virginia by informed persons. Their recommendations have resulted in the passage of a joint resolution by the legislature 4 years ago providing for a series of renewable–natural-resource studies. Water ranked high on the list.

Two principal areas of water resource interest were studied: water rights laws in West Virginia and the development of a water resources program for the state. Both studies have been completed. The first, by Marlyn E. Lugar, professor of law, West Virginia University, is in the form of a well documented report. It clearly outlines case histories and the kind of information required before the state

will be ready to embark upon a water rights program.

The second study was conducted by the author and dealt with an analysis of the state's water resources, present and future needs, and current water resource development statutes. Actually, the only statewide program in operation deals with the abatement of pollution and is administered by West Virginia's water commission. This is an excellent program and is generally adequate.

New Legislation

Based on estimates of current and future needs for the development of the state's water resources, the study on water laws recommended certain legislative actions. These were enacted into law by the 1959 session of the state legislature.

The approved water resources development act is designed to accomplish the following basic objectives:

1. That the name of the State Water Commission be changed to the State Water Resources Commission and that the membership of the commission be broadened to include two additional members
2. That the act creating the State Water Commission be amended to provide for the total development of the state's water resources
3. That the amended act provide for the following responsibilities in addition to those relating to the abatement of water pollution:

a. Administration of legislation covering water rights if and when authorized by the legislature

b. Collection of water resources data, including availability, quantity, quality, and projected needs of areas of use

c. Development of detailed water resource plans for the state's principal watersheds.

This brief analysis clearly shows that West Virginia plans "to make haste slowly." The act provides the means by which basic water resources data can be collected, analyzed, and interpreted. This is a prerequisite for the development of appropriate water rights legislation.

This program may appear somewhat involved; actually, it must be. Local resource leaders, employees of municipal water utilities, sewage and industrial wastes personnel, industrial interests, and others concerned with water use need to be thoroughly conversant with the general resource needs in their fields. They must understand the interrelationships of all resources—how each complements the other. This kind of awareness will help greatly to speed up programs designed to provide adequate supplies of water and other needed resources for a growing population, and it will strengthen the individual's position as a public servant in the community. The opportunity to serve on a team with others having similar interests is a big challenge.

Reference

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Industrial-Hygiene Hazards in the Water Supply Field

Richard H. Mansur

A paper presented on Nov. 5, 1958, at the Virginia Section Meeting, Richmond, Va., by Richard H. Mansur, Director, Bureau of Industrial Hygiene, State Dept. of Health, Richmond, Va.

INDUSTRIAL hygiene is the engineering control of health hazards that are encountered on the job. Such hazards may be dusts, fumes, mists, gases, vapors, radiation, deleterious contacts, or other adverse physical conditions. In order to accomplish control of such hazards, the Virginia Bureau of Industrial Hygiene maintains an impressive array of laboratory and field instruments which are used to locate, identify, and measure hazards of all sorts. When a potential hazard to health is found, an attempt is made to reduce or eliminate it. More often than not, the method of correction is to provide suitable ventilation for a particular process or operation. In this regard, the bureau has been able to render extremely valuable assistance. It is not, of course, proper for a governmental agency to indulge in design work, which should be done by professional engineers, but, because of the extent of the ventilation problems that may exist in Virginia water utilities, and, in view of the fact that many are municipal or quasi-municipal organizations, the bureau would possibly be able to supply a design, if requested. In any event, it could supply all necessary design criteria, including specifications for fan sets.

Chlorine

Possible exposure to chlorine gas is, of course, the most obvious industrial-hygiene hazard in water utility operation. It should not be necessary to overemphasize this matter, but a few points should be mentioned.

Canister-type gas masks are commonly used for personnel protection against chlorine gas. This is proper as long as it is realized that this type of mask affords no protection when the chlorine concentration is higher than 2 per cent. Therefore, in the event of a major leak or rupture in chlorine equipment there is no substitute for a self-contained breathing apparatus with a full-face mask to protect the eyes.

All gas masks must be stored *outside* the actual danger area in order to be available in an emergency. The bottom seal on the canister should remain in place at all times except when the mask is in use. Canisters should be replaced periodically, perhaps once a year, whether they have been used or not.

It is an excellent idea to install local exhaust ventilation in chlorine and ammonia storage areas to remove, at the source, gases escaping when gas containers are removed or exchanged.

Such systems must be carefully designed, however, rather than put together of available materials. The author recently saw a system that looked fine but would not operate properly because it was not of proper design.

It should be pointed out here that the chlorine hazard is not simply one of acute, massive exposure. Prolonged or repeated exposures to low concentrations may also cause long-term effects, such as ulceration of nasal tissue and deterioration of teeth.

Chlorine Dioxide

It is doubtful that any utility in Virginia is presently using chlorine dioxide. It should be warned, however, that chlorine dioxide is more toxic than plain chlorine, and, in addition, it is highly explosive in both the liquid and gaseous forms.

Fluoride

Many water utilities now practice fluoridation. Probably most of them use dry feeders, which, of themselves, do not present a dangerous dust hazard. The dry materials, such as sodium fluoride, sodium silicofluoride, or potassium silicofluoride, are usually received in well sealed bags. Receiving these chemicals and placing them in storage should not involve a hazard. There is a danger, however, in emptying the bags into the feeder hopper.

Some utilities may attempt to control the hazard solely by use of personal protective devices such as respirators, goggles, gloves, and aprons. All of these items are proper except for the respirators. Experience has shown that workers, in general, are reluctant to wear respirators consistently because they are uncomfortable and cause difficulty in breathing. Therefore, it is better to hood the hopper loading point and provide sufficient exhaust ventilation, making respirators unnecessary.

Some water utilities use copper sulfate for algae control. The inhalation hazard during handling of this material is not very important. It is important to enforce the use of gloves, aprons, and other protective clothing to prevent skin contact. Entry of the dry material into cuts or abrasions can cause slow-healing ulcers.

Lead Poisoning

In the past much use was made of lead and lead-containing calking compounds for the assembly of distribution systems. Probably no great hazard was involved in such assembly. The calking material was usually melted aboveground in the open, then poured in the trench at a temperature low enough to prevent fuming. There are times, however, when large sections of a distribution system must be disassembled for replacement. During this process serious illness from lead poisoning can result.

It is to be expected that a crew disassembling such pipe sections would probably use an acetylene torch; speed and convenience here would be all-important. An acetylene flame is extremely hot, however—hot enough to convert lead or lead compounds into dense airborne fumes. In the confines of a trench, exposure to such fumes would be most dangerous. For control of this hazard, it is relatively easy to use portable power exhausters to remove the fumes at the source to a point in the open sufficiently remote and downwind that serious danger does not result.

Trapped Gases

Too little attention is given to the hazards involved in entering utility

pits. Serious accidents continue. Although a pit may have been entered safely numerous times, workers should be convinced that it is always necessary to take precautions. Here are a few of the reasons:

1. There may be leakage of poisonous hydrogen sulfide gas into the pit from a sewer many feet away or from natural decomposition of organic material in the soil around the pit. Most people know that hydrogen sulfide is offensively odorous in small concentrations, but relatively few realize that the odor may not be noticed at all if the concentration is high. It is a characteristic of this gas that it rapidly paralyzes the sense of smell. If the concentration is high, this effect may be nearly instantaneous.

2. There may be leakage of methane and other gases of decomposition from a nearby sewer or decomposing soil stratum. Such gases are not odorous and are not poisonous. They can, however, easily displace all the oxygen in the pit and bring unconsciousness and death to the man who enters unwisely.

3. There may be leakage of natural or manufactured gases to the pit from a gas main located some distance away. The hazard may then be either that of oxygen displacement or actual poisoning from manufactured gas components.

4. Acidic surface water in contact with a limestone stratum can produce sufficient carbon dioxide gas to displace the oxygen in a pit. If the concentration is high enough, carbon dioxide can cause almost immediate respiratory collapse. In this connection, there may also be production of carbon dioxide through contact of highly acidic water with porous concrete.

It is wise never to assume that because one of these situations has never developed before, it will not develop before the next visit is made to any given pit.

For control of this hazard, it is always possible to use portable power ventilators, but to make control truly positive, the air in a pit should be tested before the pit is entered. Two tests are usually sufficient. There is now a good hand-carried instrument available for measuring the oxygen content of pit air, and this test should be routine. Also available are hydrogen sulfide test ampoules which are cheap and easy to use.

Solvents

Operators of treatment plants and maintenance shops may make considerable use of volatile solvents for cleaning purposes. It is hoped that the solvents in greatest use contain relatively harmless petroleum fractions. Some, however, may still be using the extremely dangerous chlorinated solvents, such as carbon tetrachloride or trichloroethylene. The dangers of this practice cannot be overemphasized. Carbon tetrachloride especially is just too dangerous to be used. It is not necessary to use it because there are several good, effective, and less toxic substitutes. A mixture of 25 per cent methylene chloride and 75 per cent Stod-Sol * solvent does as well for most jobs. If the job is really fussy, an inhibited methyl chloroform may be used. These are sold under several trade names. By comparison, any of these preparations is only about 5 per cent as toxic as carbon tetrachloride. Other solvents that are to be avoided are benzol, toluol, and xylol.

Painting and Welding

Utilities that have their own maintenance shops may be housing several

* A product of Anderson-Prichard Oil Corp., Oklahoma City, Okla.

hazards. All spray painting operations involve toxic materials which necessitate control. The solvents may be toxic, but pigments such as red lead, chrome yellow, and others are more seriously dangerous. Spray painters' respirators may be adequate for the occasional job, but where much of this work is done there is no good substitute for properly designed ventilation.

Welding always involves hazards to health. Even during light arc welding on nontoxic metals, there are dangers. The presence of dirt and grease may cause the production of harmful quanties of carbon monoxide. If the work was once painted with a toxic paint, such as chrome yellow or red lead, a poisonous fume will be raised by the arc. Gas welding, or brazing, usually involves the same hazards, but it presents others of its own. The bronze or brass rods may contain toxic lead and zinc. Fluxes, especially for aluminum, may contain fluorides, the dangers of which are well known.

Inert-gas shielded arc welding has its own special hazards. It produces a far greater concentration of ultraviolet radiation than ordinary arc welding. This may cause very serious burns to exposed or inadequately protected skin areas. In turn, the ultraviolet light produces dangerous concentrations of ozone from the surrounding air. Ozone is an increasingly common industrial poison. In the few years that shielded arc welding has been popular, a number of deaths have resulted from excessive ozone inhalation.

For the usual conventional welding setup, local exhaust ventilation is preferred. It is always cheaper and easier to pick up the air contaminant from as near to the source as possible. For inert-gas shielded welding, however, one must ventilate the whole area, because ozone may be produced over a radius of several feet from the arc.

Other Hazards

Some water utilities may use a number of mercury-bearing instruments, such as manometers and similar devices. Mercury vapor is one of the oldest known occupational health hazards. In a laboratory or shop where mercury is used and may at times be spilled, it is wise to make an occasional survey for mercury vapor. The Virginia Bureau of Industrial Hygiene does this on request.

One reservoir in Virginia has its own very special hazard. This reservoir is impounded by a dual-purpose dam. The primary purpose is, of course, water storage, and the other is power production. There are three levels from which water may be drawn. Because the reservoir is not very old, all three draft levels are in the zone of stagnation. The area inundated by the reservoir was heavily covered with growth, and the zone of stagnation contains much decomposing organic matter. From this, large volumes of hydrogen sulfide and other gases are given off. It is believed that hydrogen sulfide concentrations in the turbogenerator room and in the shaft of a self-operated elevator in the dam may be high enough to be dangerous. Recommendations for ventilation of these areas have been made.

Getting a Safety Program Started

John W. Krasauskas

A paper presented on Oct. 30, 1958, at the Chesapeake Section Meeting, Wilmington, Del., by John W. Krasauskas, Chief, Plant Operations Branch, Water Supply Div., Corps of Engrs., US Army, Washington, D.C.

THE first AWWA award program for safety in water works was approved by the Board of Directors at its annual winter meeting on Jan. 28, 1957, after a committee on safety practices had reported to the board that the water supply industry was not generally safety-conscious. This report is substantiated by Bureau of Labor Statistics and National Safety Council data, which show an accident frequency rate * for water utilities almost as high as that of such hazardous occupations as logging and lumbering.

Table 1 lists the injury rates for public utilities compared with various occupations encountered in other industries.

In 1953, the frequency rate for disabling injuries in water utilities was 22.2 and the severity rate 1,600. Comparison of these rates with those in Table 1 makes it apparent that there has been little or no decrease in the number of disabling injuries in the water supply industry from 1953 to 1956, although the severity rate during this same period improved by 20 per cent. Other public utilities, such as sanitation and sewers, also have high frequency rates, but the severity rates for all public utilities are lower than for the gas and electric utilities because personnel in these groups are not exposed to the same degree of hazard. Explosives and steel are included in Table 1 as examples of hazardous industries that have integrated safety methods so well into their procedures that the injury rate has been reduced to an extremely low level.

These figures emphasize the immediate need for safety programs in public utilities to reduce costs of operation through more efficient use of manpower. That this is not an impossible task for water utilities is well illustrated by the successful safety campaigns conducted in industries such as steel manufacturing and others that are certainly more hazardous potentially than filter plants.

Cost of Injuries

Every accident involves expense in some way, either by interference with work schedules, which results in payment of premium rates to a replacement, or efficiency losses caused by breakup of crews and job delays. These costs are indirect and cannot easily be traced, except by careful analysis of well kept records. More tangible costs, which can be computed, are the loss of wages, medical expenses, compensation, and insurance. Accord-

* Number of lost-time injuries per million man-hours of work.

ing to the National Safety Council, typical estimates for visible costs to the employer for one year are $1.350 billion, and for the indirect costs, $1.3 billion, whereas wage loss to employees amounted to $400,000,000. Compensation alone, paid out by the US government for injuries in 1956, totaled $29,000,000, and the actual cost per capita for injuries in the United States was $65 per year, or a total of $11.375 billion.

TABLE 1

Injury Rate Comparisons for 1956

Industry	Frequency Rate	Severity Rate*	Time Charged per Injury—*days*
Sanitation	39.7	1,236	31
Sewage	32.9	†	
Water supply	22.7	1,273	57
Electric and gas utilities	16.8	2,212	132
General manufacturing	12.0	712	59
Steel	3.95		
Explosives	2.5		

* Days lost or charged per million man-hours of work.
† Blanks indicate no data available.

Profit in Safety

Safety is good business. According to Harry M. Anderson (*1*) of General Motors Corp.: "The experienced plant manager knows that it is good business to accept safety as a management responsibility, to establish policies, procedures, and practices under which every member of management will clearly understand that the safety of employees is a primary responsibility at all times and that it is not to be sacrificed or jeopardized in any way." Many managements are able to show that money saved from lowered injury rates outweighs the cost of an effective safety program. In fact, one group of large manufacturers (*2*) estimated the return at $1.60 for each dollar expended. A study of accident costs by the National Safety Council (*2*) provided a figure of $4.00 of uninsured cost per dollar of insured cost. These figures proved that it costs more to have accidents than to prevent them.

Other Benefits

Other benefits to be derived from an effective safety program are increased cooperation, productivity, and improved employee morale. Every employee likes to feel that his job is important and likes to be consulted. Mutual cooperation between employees and management to foster an active safety program will improve labor relations, because an employee has a fundamental right to be heard and appreciates the acceptance of his proposals as a member of the working team. This cooperation is most important because disagreement between management and employees leads to an unhealthy atmosphere of real and fancied grievances and increases the likelihood of accidents and higher injury rates.

Safety Program Promotion

It is necessary to realize that safety is a responsibility of management, although safety cannot be management's job alone. Top management, however, can show by deed and action that it is in full accord with the principles of safety. It should give some time each month to sell safety to the employees, either to keep a campaign moving, or to trigger a new approach, because any program is only as good as the top support. The safety policy of the or-

ganization should be put in writing and be available for all employees to read.

A definite, planned program, using accepted principles of accident prevention, must be set up and followed rigorously. Safety must be implanted in the minds of all employees before any program can be a real success. If one can get an employee to think about safety, the battle is half won, because a man can avoid many accidents by using good, common sense. The large number of injuries that occur every day are an indication of a growing tendency not to think before acting. Principles of safety must be taught constantly as a reminder to think.

It would seem logical to assume that an effective, stimulating, and instructive safety program would automatically lead to a successful campaign. A steel company (*3*) found by experience, however, that a good safety program is not always enough to insure success. A study was made by steel officials, who discovered that knowing was not enough because people react in various ways to the same situation. The company then decided to use motivational research to determine which forces affecting human behavior could be utilized to sell safety.

Motivation

Motivation is defined as the stimulation of an active interest through appeal to associated interests or by special devices. Psychologists have found through motivational research that appeals that move people are often hidden. The recent television and movie stunt of flashing items on the screen for very short periods of time, so short that one is not actually aware that one saw the item, is an example of motivational research. Repeated at spaced intervals, the message unconsciously impresses itself on the viewer's subconscious mind and he later finds himself asking for and buying items he is sure he never heard of before.

To check consumer reaction to color, a color research institute (*4*) made up three boxes—one yellow, one blue, and one blue with splashes of yellow. All of the boxes were filled with the same detergent and distributed to wives for trial in their washing machines. The housewives, thinking they were using three different types of detergent, reported that the detergent in the yellow box was too strong and in some cases ruining clothes, whereas the detergent in the blue box left their clothes dirty looking; as for the detergent in the third, the blue and yellow box, it was fine and wonderful.

Because people do not always act rationally, the use of ordinary methods in safety promotion do not always succeed. The steel company mentioned previously tried all of the ordinary methods to promote a good safety campaign but were unsuccessful until they came up with a psychological gimmick called "operations attitude," which is motivation in action. They decided they had not paid enough attention to the steel workers' thoughts and attitudes toward safety rules and that if the workers helped to make the rules they would hesitate to break them. Ideas were solicited from the men in a conference atmosphere and a rough draft was typed for inspection and approval, after which the ideas became standard operating procedure. A half-hour movie was made to demonstrate that knowing about safety is not enough. A poster depicting four "Imps"—Improvising, Impatience, Impulsiveness, and Impunity—who could

get men into trouble, was devised for dramatic effect. Progress reports were posted. Success was almost immediate. This novel and original approach is one of many schemes that will work to sell safety.

When one looks for a motivational gimmick, either to start a program or to salvage a lagging program, one must remember that people are not always rational in their actions. As a general rule, however, they cooperate willingly toward a goal if in some way it satisfies a personal need.

Program Activities

The seven specific activities (*5*) that should be carried on to develop a safety program are: placement, training, education, corrective action, supervision, arousing safety interest, and employee participation. Any or all of these activities may be used, depending upon the size of the installation.

Placement is most important because the mental and physical characteristics of any one individual may make him accident-prone.

Training should be a process of telling, showing, correcting, and continual supervision to ensure perpetuation of good safety habits.

The three R's in education have their counterpart in the three E's of safety, namely: engineering, education, and enforcement. Safety, as part of engineering, should be built into all normal operations and included in the design stage of new construction. Education, which is the broadening of one's knowledge and understanding, should be combined with training for best results. Enforcement of safety regulations must be fair but firm, because corrective action is a very important part of any safety program.

The supervisor can make or break a safety program. Therefore, it is important to train and educate the supervisors in safety practices so that they can search out unsafe conditions, report all accidents and injuries, enforce safety rules, and instruct personnel to be safety conscious. The best safety device is a careful worker, but the key to a good safety record is an alert supervisor.

Safety interest can be aroused and maintained through the use of devices such as safety meetings, safety contests, suggestion boxes, plant publications, bulletin boards, slogans, signs, movies, and so forth.

Employee participation in safety activities will result in increased cooperation and a well organized safety program. Joint meetings can be held with two or three employees at a time, letting them list the job hazards from personal knowledge and then helping to outline the safe way to do the job. Safety committees should be appointed and instructed to hold regular meetings.

Many states have safety departments to inspect work places for conformance with safety practice. One can use this inspection service to pick up deficiencies in his plant and eliminate the causes of accidents. The local fire department should be asked to make an inspection of the plant and to report fire deficiencies that can be corrected. Copies of state codes should be secured and carefully studied.

Safety manuals such as *Safety Practice for Water Utilities* published by AWWA, *Safety Subjects* by the Department of Labor, the *Supervisor's Safety Manual,* a manual by the Corps of Engineers, US Army, are recommended for ideas and details in

starting a program and for installing safe working practices in plant maintenance and construction operations. For maintaining interest after a program has been started, there are the National Safety Council magazine for supervisors, the *Industrial Supervisor,* and a booklet for the worker, *The Safe Worker.* These are most informative and supply excellent safety material that can be used in a training program. Other manuals on specialized safety subjects are available and are listed in the AWWA safety manual, *Safety Practices for Water Utilities.*

A safety course for supervisors, consisting of 30 hr of instruction, is conducted by the Department of Labor upon request, and a handsome certificate is awarded for satisfactory completion of the course.

One cannot overemphasize the importance of selling safety; the cost of risking life is much higher than the cost of living.

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Decontamination of Ground Water at Indian Hill

Warren W. Parks

A contribution to the Journal by Warren W. Parks, Village Mgr., Indian Hill, Ohio.

THE insidious nature of ground water contamination and the time required for contaminated water to regain its original quality after the contamination has been stopped at its source are demonstrated by the experience of Indian Hill, an incorporated village, near Cincinnati.

The village water system obtains its supply from four wells drilled about 70 ft deep into the alluvium in the Little Miami Valley. These wells are in a line approximately parallel to and 100 ft from the west bank of the Little Miami River.

Treatment consists of softening by ion-exchange filtration, threshold treatment with sodium hexametaphosphate for corrosion control, and disinfection with chlorine, the latter two fed by proportional feeders. The average pumpage is about 1.5 mgd. A residential population of 12,000, which includes two adjoining communities, is served by this system.

The water plant was first placed in operation in November 1949. Water brine from the 700 lb of salt used in each regeneration of each zeolite filter was discharged into a small drainage channel tributary to the Little Miami River about a half mile downstream from the well field. The original point of discharge was approximately 850 ft from the nearest well, at right angles from the river. Figure 1 shows the locations of the wells.

For the first 4 years of operation the chloride concentration in the well water was practically the same as the adjacent river water, which was 10–20 ppm.

Late in 1953, the chloride content of the well water began to climb rapidly (Fig. 2). It was not realized what was causing the rise in the chlorides until October 1954.

It then appeared evident that the concentrated brine being discharged into the dry channel was finding its way to the well field, especially to the downstream section, where the first well was drilled.

As a solution to the problem, the drain carrying the brine discharge was extended 1,000 ft downstream. This was done in two 500-ft sections, the first being started in November 1954, and immediately halted the rise of chlorides. The entire extension was completed in November 1955. As can be seen from Fig. 2, the decrease in chlorides was as rapid as its climb once the source of contamination was removed.

Two other operations were also put into effect and played important parts in restoring the normal chloride content of the well field. First, well No. 4, which was located in the most contaminated area, was operated continuously for nearly 2 years, discharging only into the river, and none of the discharge entered the water system. The second rather drastic step was to dig an immense pit (100 ft × 30 ft and 20 ft deep) in the gravel west of the wells and pump river water into the pit in as large a quantity as would filter back into the well field through the gravel. At no time did any pollution develop, and the low chloride content of the river water helped to dilute the concentrations which had built up in the well field. This was continued intermittently for several months.

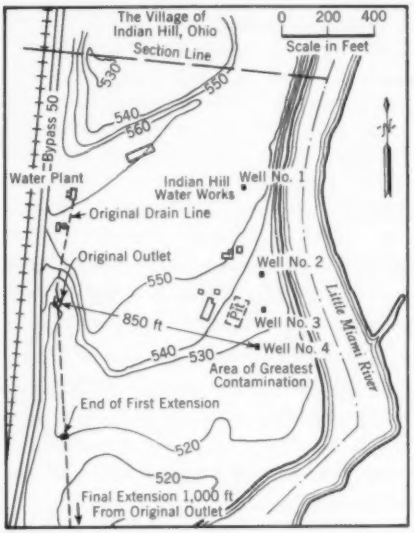

Fig. 1. Areas of Ground Water Contamination, Indian Hill, Ohio

The pit shown to the left of wells No. 2 and 3 was dug to aid in decontaminating the ground water. River water was pumped into the pit and then filtered back into the well field, thus reducing the chloride content of the ground water by dilution.

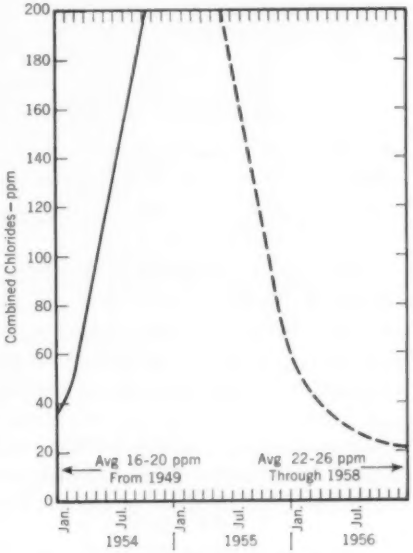

Fig. 2. Record of Combined-Chloride Content in Well Water, 1953–56

The solid curve represents the rise in concentration before the discovery of the presence and source of pollution. The dashed curve represents the decline after corrective measures were begun. The maximum concentration of chlorides in any single well (not shown) was 744 ppm.

That the methods used to bring back normal conditions were justified is indicated by Fig. 2, from which it can be seen that chloride content was nearly back to normal by the summer of 1956. This condition has continued to date.

These experiences have demonstrated that on even a local scale, pollution of ground water sources may occur gradually over a period of years before it is recognized and that, even though pollution is detected and the source eliminated, it may take a very long time for the water to regain its original quality.

The problems of cleaning up a contaminated ground water supply are far more difficult and time-consuming than those of pollution removal from surface water.

Correction

Through an editorial oversight, a significant statement was deleted from George R. Evans' discussion of the article, "Use of Microstrainer Unit at Denver," by George J. Turre (March 1959 JOURNAL, pp. 354–62). In referring to the Marston Lake South Side Filter Plant, mentioned by both Turre and Evans, it should have been pointed out that this is a tub filter installation built 50 years ago (and scheduled for retirement in the near future). Hence, the high wash water consumption figures for this plant which are shown on p. 358 and in Table 2 on p. 360 should not be regarded as average for, or even representative of, the wash water consumption at Denver's other plants.

Sanitary Engineering Appraisal of Waste Water Reuse

Henry J. Ongerth and Judson A. Harmon

A paper presented on Oct. 29, 1958, at the California Section Meeting, Los Angeles, Calif., by Henry J. Ongerth, Sr. San. Engr., and Judson A. Harmon, Supervising San. Engr., both of the Bureau of San. Eng., State Dept. of Public Health, Berkeley, Calif.

IN this period when adequacy of water resources has become a matter of public concern in many parts of the country, it is natural that there should be increasing professional and public interest in the possibility of waste water reclamation. This article will briefly summarize the historical development of waste water reclamation, describe ways in which waste water may be utilized, and discuss the engineering, public health, economic, legal, and aesthetic problems that must be faced in reclamation of waste waters. In a broad sense, waste water reclamation implies reuse of all waste waters, including agricultural waste waters; also, waste waters discharged into streams may be recovered by withdrawal of flow farther downstream. The discussion of reclamation presented herein will exclude these two reuses.

There is little that is new about the problems involved in reclamation operations. Extensive experience has demonstrated that waste water reclamation can be accomplished safely and satisfactorily by the application of well known sanitary engineering principles.

In this presentation, the expression "waste water reclamation" is used to overcome public aesthetic—or, more properly, semantic—objections to the term, "sewage."

Reclamation Methods

Reclamation of waste water may be accomplished by any of the following operations: ground water recharge, either by percolation from the surface or by direct injection; crop irrigation; domestic irrigation, particularly lawn watering in parks and golf courses; other, secondary domestic uses, chiefly toilet flushing in institutional premises; and treatment for specialized industrial uses.

Ground water recharge by percolation of effluent from household sewage disposal units is undoubtedly the oldest and most frequent kind of waste water reclamation, although today it represents only a small proportion of the domestic sewage of the 175,000,000 people of this country. This recharge, along with effluent disposal from some community sewage disposal works, is usually the unintentional or incidental consequence of spreading sewage on or immediately under the ground surface for final disposal. The engineering problems associated with this type of operation are generally limited to those of sewage disposal.

Crop irrigation is another long-practiced use of waste waters, employed largely as an aid in the disposal of community wastes, with irrigation use being merely incidental to the disposal

operation. "Sewer farms," where crops have been raised and livestock has sometimes been pastured, have been operated as an adjunct to sewage disposal primarily to produce revenue partly to defray costs of disposal. Unfortunately, often the tail has ultimately wagged the dog and successful disposal has suffered because of a concern for the agricultural operation, and sewage disposal has been discontinued on the farm and released to natural channels to prevent damage to crops.

Industrial reclamation is also important, in terms of historical development and magnitude of application. Two well-known examples, differing in source of water, are the Bethlehem Steel Company's plant at Sparrow's Point, Md., which uses effluent from Baltimore's domestic sewage treatment plant (*1*), and the Kaiser Steel Company at Fontana, which reclaims industrial and domestic wastes from its own plant (*2*).

Secondary Domestic Reuse

Secondary domestic uses limited generally to lawn watering and toilet flushing are, with a few notable exceptions, relatively recent developments and few in number. Some of the earliest of these domestic operations have been in the West. In chronological order of initial operation these are:

1. Grand Canyon National Park, where domestic sewage effluent was first used at the park in 1926 for toilet flushing, lawn sprinkling, cooling water, and boiler feed water at the power plant (*3*).

2. Pomona, where municipal sewage treatment plant effluent has been used for domestic irrigation of lawns and gardens in a suburban, semirural, home development area since 1929 (*4*).

3. San Diego State Teachers College, where domestic sewage plant effluent was first used in 1931, primarily for lawn and shrubbery irrigation (*5*).

4. Golden Gate Park, San Francisco, where activated-sludge plant effluent was first used in 1932 for park lawn watering and to maintain water levels in some of the park lakes (*6*).

At San Diego State Teachers College use has been abandoned, and the Pomona operation has been taken over by the Los Angeles County Sanitation District. At the other two locations use continues and plans are now under way for a major expansion of the Golden Gate Park plant use (*7*).

Water reclamation through recharge of ground water basins may also be accomplished by injection of reclaimed waters directly into porous strata, either water bearing or potentially water bearing. This method has been little applied until now, but it is receiving serious consideration in some areas and may become an important means of waste water reclamation in the future (*8, 9*).

Interest in waste water reclamation at the present time is centered particularly on direct, industrial reuse and on direct recharge of ground water basins. The costs and benefits of projects for direct reuse can be reliably determined and the charges placed on those benefited. With indirect reuse accomplished through recharge of ground water basins, determination of those who benefit will be difficult and there may be no legal basis for charging for the benefits. Furthermore, reclamation through recharge of ground waters cannot be closely controlled because it is difficult to determine the character of waste water as it mixes with the ground waters and distributes through the basin. In addition to the sanitary-engineering problems, legal considerations are especially pertinent where indirect reuse, not amenable to close con-

trol, may infringe upon the rights or property of others. In all waste water reclamation projects, the reclamation operation must be recognized as being separate from waste disposal. It is something that takes place after obligations for waste disposal have been met.

In planning reclamation projects, two considerations override all others: public health and economic. Waste waters will not be reused if the cost of the reclaimed water is greater than the cost of water obtained from alternative sources. Moreover, no project can be tolerated if it results in a significant hazard to the public health. By application of sound, well established sanitary engineering principles, all of the methods listed above can be, and have been, used without hazard to public health.

In general, when domestic sewage is involved, the more direct a reuse is, and the closer human contact is with the reclaimed wastes, the greater the public health risk. In any reclamation project there is some element of risk of public health hazard. The hazard stems from the fact domestic sewage may be infectious because of the presence of pathogenic organisms, including bacteria, viruses, intestinal worms, or protozoa (*10*). Moreover, certain industrial wastes may contain materials toxic to human beings (*11*). Because such risks exist, reclamation involving domestic sewage must be established as necessary and in the public interest before a decision is reached to establish a project.

It is not within the scope of this paper to discuss methods of treatment to prepare waters for reclamation. The treatment involved presents no new or unusual problems once the necessary degree and type of treatment are determined. It is certain that, depending upon the character of the wastes to be handled and the use to be made of them, treatment processes well understood and established for waste disposal treatment and water supply treatment will be utilized. In general, it may be said that control of pathogenic organisms is accomplished more readily than removal of dissolved chemicals. It can usually be anticipated that the removal of these chemicals from waste waters will be difficult and costly.

Underground Recharge

Recharge of underground strata by percolating waters long distances through the ground has in many instances been accomplished without hazard to the public health, whereas direct recharge of the underground by injection of degraded waters directly into water-bearing strata may be hazardous. Limited but significant information is available on the travel of pathogenic organisms through geological formations (*12–16*). Most of the information available concerns the travel of bacteria. Little is known about travel of pathogenic viruses. Within this limited framework it is possible to draw a few important conclusions. The travel of bacteria is limited to about 250 ft in the water table in sandy formations. Travel is longer in coarse formations and longer still in the water table; travel is vertical in dry, homogeneous, porous formations. Viruses travel farther than bacteria, and all other pathogenic organisms probably travel shorter distances than bacteria. It is certain that injection of contamination directly into the ground water table presents a greater hazard than surface recharge. The material being injected must for these reasons be treated adequately before discharge to render it relatively innocuous.

Recharge by injection in California must not be in conflict with the sewer well law. Section 4458 of the California Health and Safety Code states:

> No person shall construct, maintain, or use any sewer well extending to or into a subterranean, water-bearing stratum that is used, or intended to be used, as or is suitable for a source of water supply for domestic purposes. [The term] sewer well, as used in this section, includes all of the following:
>
> A. Any hole dug or drilled into the ground and intended for use as a water supply, which is abandoned and is being used for the disposal of sewage
>
> B. Any hole dug or drilled into the ground [and] used or intended to be used for the disposal of sewage.

Further, Section 5410 of the California Health and Safety Code defines sewage as follows:

> "Sewage" means any and all waste substance, liquid or solid, associated with human habitation, or which contains or may be contaminated with . . . excrement. . . .

Although large-scale experiments on the injection of sewage effluent from the Hyperion Plant of the city of Los Angeles have been successfully conducted by the Los Angeles County Flood Control District (*17*), no permanent projects for direct injection have been established in California. Hence, there has not as yet been a determination as to what constitutes compliance with Section 4458 of the code. The major problem is to determine legally when reclaimed waste waters are no longer sewage. A corollary question is, does a recharge operation constitute a disposal? These questions are unanswered and will require both legal and engineering decisions as yet not made. The primary objective of the law is, of course, to protect the ground waters, and interpretations should be made in the light of this objective.

All ground water replenishment projects, whether by surface application or by injection, will be affected by the percolation capacity of the formations receiving the water. The capacity of formations to percolate water may be reduced because suspended particulate matter may clog pores; and dissolved materials, both organic and inorganic, may promote biological growths (slimes) which physically clog formations. Moreover, chemical clogging may occur from changes in soil particles caused by chemical interaction of the dissolved chemicals in the applied waters with the soil itself.

Coarse formations do not clog so readily as fine formations. Some of the coarse debris cones of Southern California may be usable for reclamation and need little special treatment to control clogging. Formations of fine gravel, sand, or clay, tend to clog more readily. Therefore, in such formations a high degree of treatment will be necessary to accomplish the injection of sufficient quantities at a low enough pumping cost to make the project worth while. In very coarse formations, the development of slimes may be necessary to reduce travel of bacteria. In such coarse formations, even with the slimes, percolation rates may continue to be economically feasible. Where biological clogging must be controlled for successful replenishment, such control is usually attained by chlorination. Much work has been done along these lines by oil producers disposing of oil field brines by injection into the originating formations. Oil field brines are generally low in volume, and it has been economically

feasible to inject them at a high head loss. Moreover, heavy growths of biological slime do not occur because these waters usually contain little organic matter. Reclaimed community wastes, on the other hand, are relatively high in organic matter even if pretreated to a high degree.

It is doubtful that the public will accept recharge of water-bearing strata from which its domestic supply is derived unless the injection point is sufficiently distant from water supply wells to permit both time of travel and dilution with natural waters in the ground water basin. In no planned reclamation is sewage being reclaimed for unlimited domestic uses. Therefore, the public may be expected to be particularly sensitive, and special restrictions and safeguards appear justifiable.

Crop Irrigation

The use of reclaimed domestic sewage for agricultural purposes may or may not result in serious public health problems. This depends upon the crops to which such waters are applied and on the amount of treatment such waters receive prior to application. It is widely believed that uncooked vegetables irrigated with sewage will transmit disease. An extensive review of the effect of sewage on food crops as related to disease transmission has been made by Rudolfs and his associates at Rutgers University (*18, 19*). The California State Board of Public Health many years ago recognized this problem and dealt with it because sewage has long been utilized to irrigate certain crops in California. Sections 7897–7901 of the California Administrative Code, Title 17, have been promulgated by the State Board of Public Health. These regulations state, in part:

> Effluents of septic tanks, Imhoff tanks, or of other settling tanks, or partially disinfected effluent or sprinkling filters, or activated sludge plants or similar sewages, shall not be used to water any growing vegetables, garden truck, berries, or low growing fruits, such that the fruit is in contact with the ground, or to water vineyards or orchard crops during seasons in which the windfalls or fruit lie on the ground. . . . Nursery stock, cotton, and such field crops as hay, grain, rice, alfalfa, sugar beets, fodder corn, cow beets, and fodder carrots may be watered with such settled or undisinfected or partially disinfected sewage effluents, provided that no milch cows are pastured on the land while it is moist with sewage. . . .
>
> The foregoing restrictions do not apply against the use of well oxidized, nonputrescible, and reliably disinfected or filtered effluents which always meet the following bacterial standard; in any twenty consecutive samples from which five 10-ml portions each are examined, not over 10 portions shall be positive for members of the coliform group and in no single sample shall over one-half the 0.1-ml portions of the same sample be positive for coliform.

In essence these regulations state that undisinfected sewage, as measured by the coliform test, must not be used on food crops which may be eaten raw, and further, sewage effluents should meet certain relatively high bacteriological standards for unrestricted crop irrigation. These standards apply most obviously in cases of direct use of sewage effluents. A difficult question to answer is what limitations are necessary on irrigation use of natural waters contaminated by upstream discharges of sewage. This type of reuse is outside of the scope of this article. There should be no question, however, that stream waters containing sewage poorly treated, only partially diluted

and not significantly changed in character by time of travel would not be safe for use on the food crops listed above.

There has been some criticism by professional engineers of the strict bacterial standards set by these regulations for unrestricted crop irrigation. Experience in California, however, shows that reclamation by means of crop irrigation can be planned and accomplished by raising crops not intended for human consumption without adversely affecting the economy of the reclamation project. Thus there appears to be little necessity for accepting the risks of the application of a possibly unsafe waste water on truck crops. All farms irrigated in California at this time comply with the regulations on kind of crop irrigated.

Industrial wastes not contaminated by human sewage may be used for crop irrigation without presenting hazards to the public health and are not subject to the California regulations. Some industrial wastes may, however, contain chemicals detrimental to crop development. For example, boron is extremely toxic to many plants. The effluents from domestic sewage works are usually safe as far as boron content is concerned, but a single application of industrial water containing as little as 15–20 ppm boron would probably kill boron-sensitive plants and necessitate reclamation of the soil.

Industrial wastes resulting from the manufacture of insecticidal and herbicidal chemicals constitute one of the greatest hazards. There is no easy way to detect some of these chemicals or to eliminate them from the water. Some are so extremely toxic that a single application of contaminated irrigation water has killed the crop and rendered the soil sterile.

These problems add to the difficulties that are associated with ordinary irrigation agriculture. The solution is not easy although automatic control devices might warn of the change in total salts concentration and would help to that extent. Storage in relatively large reservoirs would tend to dilute the concentration of toxic substances. Mixing an effluent with a large volume of good irrigation water is perhaps the best method and this method has been used successfully for many years (*20*).

Acceptable limits for common chemicals naturally occurring in waters are well known and have been discussed in the literature (*21*).

Industrial Reuse

Industrial uses of reclaimed waste water vary greatly; a comprehensive discussion of the public health problems associated with uses of wastes containing human sewage can therefore be presented only in general terms. Three kinds of problems appear to be of major importance: accidental individual use of reclaimed sewage, accidental interconnection of secondary-water piping with domestic-water piping, and various kinds of worker contact with contaminated waters. All three hazards can be significantly reduced if the reclaimed waters are essentially free from pathogenic organisms. Absolute freedom from such organisms is difficult and often impractical to achieve when domestic sewage is involved. Standards for water of secondary quality are usually based on the number of coliform organisms, but it should be recognized that such a criterion does not provide an index to the hazard of viruses and protozoan pathogens. As a minimum, it would seem desirable that domestic sewage receive at least primary treat-

ment followed by a reasonably effective disinfection. Such disinfection is more effective in controlling pathogens if the sewage being disinfected has received secondary treatment in the form of some sort of oxidation process.

Even with the best treatment, there must be limitations on the uses of reclaimed water in certain industries if there is any remote possibility that the water carries any human wastes. For example, such water would not be acceptable for use in the food-processing industry.

It is not within the scope of this paper to give a dissertation on problems of cross-connection hazards and on methods of cross-connection control. Briefly, if a secondary, potentially hazardous water is piped around any premises, accidental interconnections may be made between the domestic water system and the secondary water source. The degree of hazard depends upon the complexity of the piping arrangements, the management of the piping operations, and the effectiveness of protective measures, such as good piping plans, differential marking of the two piping systems, and good administrative control. When secondary water systems exist, the cross-connection hazards must be recognized and dealt with intelligently and unconscientiously.

Experiences in the past have demonstrated that water from the secondary-water system is sometimes used unwittingly by workers around the plant. Suitable means must be devised to meet this problem. Differential marking of pipes, adequate marking of the outlets, and, possibly, the use of special control valves that can be operated only by certain personnel are some methods that may be employed to deal partially with this problem. Dyes or such taste-producing substances as phenols may also be utilized. Employee education should not be ignored as a further means of meeting the problem.

Worker contact with degraded waters is different in various industrial operations. There may be little or no worker contact, and the required quality of the secondary water may be determined by the extent of cross-connection and accidental-use problems. If there is relatively intimate worker contact with the secondary-water supply, a better quality of water should be maintained, or, in other words, more rigid bacterial standards should be met.

When industrial use is made of reclaimed domestic sewage, additional treatment is usually required after normal sewage treatment. This additional treatment may be provided by the operator of the sewer system or by the user of the reclaimed water. Both practices have been followed in the past.

It is probable that significant increases will occur in industrial uses of reclaimed waters. It is likely that more industries will utilize their own waste waters than will used community sewage. This affords a means of reusing substantial quantities of waste water, thereby accomplishing a significant reclamation.

Secondary Domestic Uses

So-called secondary domestic uses, particularly toilet flushing, should be practiced only where adequate controls can be maintained. Such secondary uses are found in certain military establishments, such as the Marine Base at Twenty-Nine Palms, Calif. (*22*), and at Grand Canyon National Park. These secondary uses present public

health problems primarily from cross connections and accidental use of water from improperly identified piping. One reason why such secondary uses have been limited to institutional facilities is the difficulty of adequately controlling the cross-connection problems on a community basis. Within institutions the problem of accidental use of water from the secondary system can be controlled if no taps are available for accidental use and water service is restricted to toilet bowls and urinals. Nevertheless, a minimum quality of water must be maintained for a satisfactory secondary line of defense in the event of accidental use of the supply.

Domestic Irrigation

Domestic irrigation uses of reclaimed sewage present significantly different and troublesome public health problems, chiefly because of the greater opportunity for contact by the public with the reclaimed waters or with lawns and other grounds that have received applications of the water. The degree of hazard through contact with irrigated lawns is difficult to assess, but prudence should dictate a high level of protection. In addition to the cross-connection problem and the possibility of accidental use of water from the secondary piping system, the possibility of people coming in contact with sprays on golf courses or lawns is a public health concern. Without question, such exposures have occurred and can never be completely eliminated. This and contact with the irrigated lawns and grounds constitute more serious exposure and therefore represent more serious hazards than the other two hazards. As a result, a higher standard for water quality and treatment is necessary than for the uses previously described. An important consideration in this case is the reliability of the waste water treatment operation. Under ordinary circumstances, reliability of sewage treatment operations is considered desirable but not an absolute necessity, but, where waters are reclaimed for certain uses, reliability of operation becomes a necessity. Reliability of operation may necessitate the installation of duplicate treatment equipment, high-caliber operation, more specific controls, both laboratory and administrative, and secondary safeguards such as storage (30 days or more) in advance of the use. Unless these safeguards can be provided, and unless the cost of meeting them is taken into account in assessing the cost of the operation, reclamation projects should not be carried into operation.

Some further mention should be made of the public health hazard from exposure to sprays from sprinklers on lawns. Only very limited information is available concerning possible disease transmission from contaminated sprays. In California, the public health department demonstrated the presence of sewage organisms in the air in the vicinity of contaminated bay waters at a time of wind and wave action in unpublished studies of 1939 and 1943. More recently, research workers at the University of Southern California studied the matter and reported their findings briefly (*22*).

Legal Aspects

Consideration of waste water reclamation raises questions as to how legal rights to reclaim waste water are acquired, which public agencies are empowered to reclaim waste water and make it available for reuse, and the problems of liability for damages that may result from reuse of waste water.

These questions were discussed by Adolphus Moskovitz, Deputy State Attorney General, in a paper presented at the Conference on Waste Water Reclamation at Berkeley in 1956 (*23*).

Rights to use water may be either *riparian*, by which the owner of land bordering a natural watercourse may use a fair share of the natural flow and must return this flow to the watercourse unimpaired in quantity or quality after making reasonable use of it; or *appropriative*, by which those not having riparian rights may acquire a right to use water within the originating watershed or to import it to and use it on another watershed. Both riparian and appropriative users may reclaim and reuse water instead of abandoning it to be recovered by others. There is a difference, however, in that the riparian user must ultimately permit return of the water to the stream from which it was derived. An appropriator of water may use the water on land lying in another watershed and has no obligation to return the water finally to the original stream.

If the original appropriator does not wish to engage in reclamation and reuse of water himself he may sell it to someone else. Moreover, the owner and operator of a sewerage system which is in control of waste water may be considered either to be in possession of abandoned waste water, or to have been granted the right by the appropriator to all future use of the water. In either case, the owner of the sewerage system would have the right to reclaim and reuse the water himself or to contract to deliver it to others for reuse. Contracts of this type have been entered into in California.

In general, cessation of pumping in favor of using reclaimed water may result in loss of rights by users of ground water, especially in an area whose natural supply is being overdrawn. An exception to this general rule exists in certain areas of Southern California as the result of statute revisions by the California Legislature in 1951. Sections 1005.1 and 1005.2 of the California Water Code provide that under certain specified conditions, cessation or reduction of the extraction of ground water by an owner with a right to do so as the result of the beneficial use of water from an alternate source will not impair that owner's rights to water in the ground water basin in question.

A large number of California public agencies are specifically empowered to reclaim waste water and distribute it for reuse. These include many agencies for the collection and disposal of wastes, as well as agencies empowered to obtain and distribute water. Cities also have the express power to lease sewage and treated sewage effluent for a period not to exceed 50 years. A few public agencies may engage both in waste collection and disposal and in the supplying of water for beneficial purposes. Such agencies are particularly useful in waste water reclamation because they can acquired a supply of water, distribute it to their consumers, pick it up as waste water, treat it, and then put it back into a secondary-water delivery system for reuse. Agencies with these powers include cities, county water districts, community service districts, public utility districts, and municipal utility districts.

Because inadequately treated waste water may contain harmful amounts of chemicals or disease-producing materials, injury may result to users of such waters. Therefore, those who supply waste water for reuse must pro-

vide for its treatment by effective artificial or natural means to the extent necessary to make it suitable for its intended use. Otherwise, under the general rules of negligence, they may be liable for the damages caused by the presence of harmful materials. Any negligent breakdown of treatment processes may also expose the operator to liability for damages occurring as a result. This liability may be eliminated or reduced by contract if the seller of a reclaimed water provides in the agreement that the buyer assume all the risks of damage that may result from its use (*23*).

General Aspects

As in all engineering works, the designer must have good information on the characteristics of the material with which he is dealing. This applies particularly to chemical quality of used water. In areas of normally soft water, domestic sewage free from industrial wastes will, except for its organic content, not differ greatly in chemical characteristics from the water supplied to the community. This is not true where the community has a hard-water supply, because wastes from household water-softening units may contribute a substantial chemical load. Furthermore, in areas of mineralized ground waters the sewage character may be influenced by ground water infiltration.

Wastes from some industries are high in chemical constituents. Engineers expert in waste disposal, as well as water treatment, are aware that removal of dissolved chemicals is costly. It is unlikely, therefore, that many reclamation projects will be found economically feasible where chemicals must be removed to make the reuse possible. It may therefore be necessary to discard those waters that would grossly degrade an entire flow by segregation of low-grade industrial wastes from good-quality water within the industry or by separate collection of certain industrial wastes from domestic sewage in the community.

In the ultimate development of a reclamation plan, the cost of segregation and separate collection may be significant, and the cost of segregation should probably be considered a charge against the cost of water reclamation and not a charge imposed upon the waste discharger. In this context, it is worth noting that there are limitations upon the character of waste materials that may be discharged into certain sewer systems. For example, at Pomona, the city, and more recently the Los Angeles County Sanitation District, excluded citrus wastes containing boron and paper mill wastes from that portion of the community sewer system from which the sewage to be reclaimed is taken.

It should be obvious that industrial wastes vary widely in their characteristics. Some industrial wastes may be reclaimed at little cost, whereas others can be reclaimed only at excessively high costs. In general the cost of reclaimed water may include cost of segregation, cost of treatment as necessary for the reclamation operation, cost of transportation and distribution, and cost of public health controls. The sum of these costs must be less than the cost of a competing raw-water supply, or a reclamation project is not economically justifiable.

Aesthetic Considerations

Investigators have pointed out that the public may object to certain waste water reclamation projects because of

aesthetic objections to reclaiming sewage. In a current magazine article describing nationwide problems of water resources, the following statement is made: "Already many Americans are drinking what may be accurately—if disgustingly—described as treated sewage" (*24*). This statement must certainly represent the opinion of a large segment of the American public. The experience at Chanute, Kan., seems further to demonstrate that the public will not accept reclaimed sewage water for unlimited domestic purposes (*25*). The best way to meet aesthetic objections is probably to introduce a significant separation by time and distance between the reclamation operation and the use, regardless of the kind of use. If the public is unaware of the origin of the water they will have no aesthetic objections, so long as the water is not otherwise objectionable to their senses. Downstream users of surface waters from major streams apparently have little aesthetic objection to the waters they are using after such waters have been subjected to adequate treatment. On the other hand, if the public is aware that reclamation is taking place, the developers of a project must create public confidence. Such confidence is merited and may be commanded only when reclamation projects are developed along sound engineering lines. Projects must be conceived and planned by competent engineers having adequate knowledge of, and experience with, the engineering principles involved. In some kinds of reclamation the scientific principles are well established and projects may be successfully carried on with no doubts about the quality of the reclaimed waters. In other cases, the scientific principles and their application are not fully established, and development must come more slowly. There is an element of pioneering in reclamation projects, and the responsibility rests with those who would carry them out.

Recent articles have emphasized the rapid growth in population in the United States, particularly in the arid Southwest. To quote one article:

> Our population is climbing at an annual rate of 3,000,000—the equivalent of adding to our country each year another Los Angeles. . . . We will be crossing the historic 200,000,000 total in only 8½ years . . . there is no missing the significance of this population explosion. More people need, want, and consume more goods and services (*26*).

The immediate question is where the water is to come from for these people. The problem of adequate water supply is a challenge which may be partially met by incorporation of waste water reclamation in the development of water resources.

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Analysis of Treatment Costs at Cleveland, Tenn.

Ellis L. Spencer

A paper presented on Sep. 23, 1958, at the Kentucky-Tennessee Section Meeting, Memphis, Tenn., by Ellis L. Spencer, Supt., Cleveland Water Works, Cleveland, Tenn.

THE inability of water utilities to adjust their rate structures to increases in the cost of operations and materials causes a great deal of concern. Although rate increases are undesirable from most viewpoints, they are nevertheless sometimes necessary. In order to justify such increases to the public, it is essential that utilities keep accurate records of all costs and set up a standard cost-accounting system so that the cost of every phase of water utility operation and maintenance, from the raw-water intake to the consumer's faucet, may be determined.

One major element that must be carefully analyzed is the cost of water treatment. Once this has been determined and related to every other element of utility operation, standard management procedures can be formed. The ultimate purpose of such an analysis is a financially well timed, planned program of construction and preventive maintenance that can meet the needs as they arise.

General

The city of Cleveland, Tenn., has two sources of water supply. One is a series of springs located at Waterville, approximately 4½ mi south of Cleveland. These springs are clear and require only chlorination and fluoridation, both of which are provided at the pumping station. The other source of supply is the Hiawassee River, located about 12 mi northeast of Cleveland. This river has a minimum flow rate of 160 mgd. Located at the river is a raw-water–pumping station designed and built for a maximum capacity of 6 mgd. A 20-in. raw-water main conveys the raw water about 5 mi southwest toward Cleveland, from the pumping station to the filtration plant. River water requires the regular treatment. The filter plant is presently designed for capacity of 2 mgd, with provisions to expand to 6 mgd by the addition of filter beds and settling basins.

The pumping station at Waterville Springs is operated continuously at full capacity (except during extremely dry periods) and pumps directly into the distribution system, which is connected to the reservoirs located on the northeastern side of Cleveland. The amount of pumpage from the springs is dependent almost entirely on demand and very little goes into storage. Additional water demand above the demand capacity of the springs is supplemented by the filtration plant.

Breakdown by Source

As the methods of treatment of each of Cleveland's sources of supply are different in scope and nature, it stands to reason that the unit cost of treatment of each should be considered separately and then combined to obtain an overall unit cost.

Also there is a wide variation in pumping demand upon the filtration plant, and it is desirable to determine the unit cost of treatment at the various stages of demand from the minimum to the present plant capacity of 2 mgd.

In order to determine the unit costs at various stages of production at the filter plant, the variable and fixed unit costs have been calculated and presented separately in graphical form and then combined to give a composite cost curve (Fig. 1). The pumpage at Waterville varies somewhat, but to a lesser degree, and is also presented in a manner similar to the filter plant cost (Fig. 2). The final curve shows the

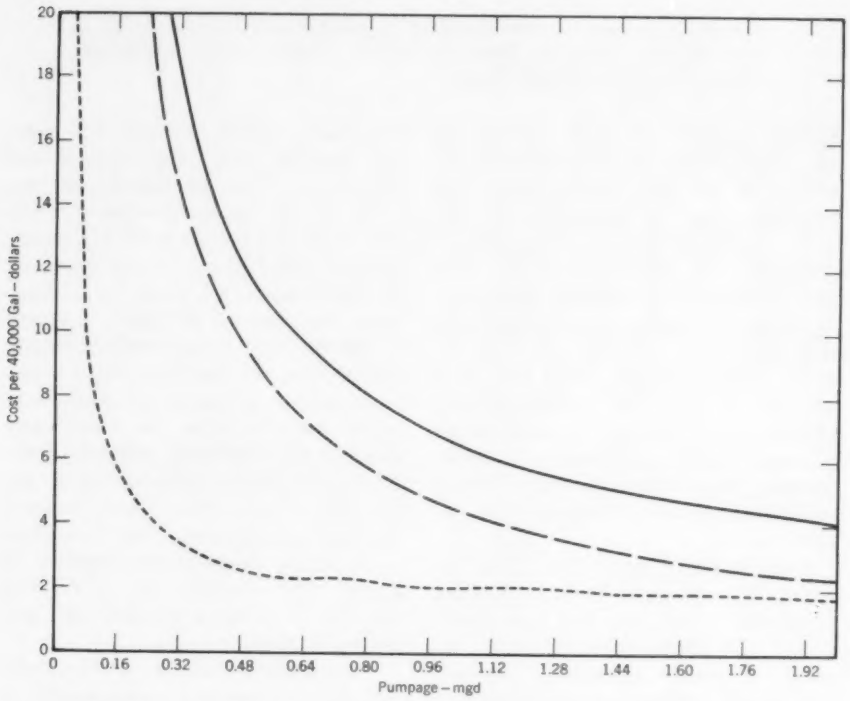

Fig. 1. Fixed-, Variable-, and Combined-Cost Curves, Filtration Plant

The short-dashed, long-dashed, and solid curves represent, respectively, variable, fixed, and composite (sum of variable and fixed) costs for a demand range of 0.40–2.00 mgd.

combined unit cost of production from both sources (Fig. 3). These graphs and detailed information related to their construction are in the explanations that follow. No attempt, however, has been made to determine any cost beyond the point of treatment.

Types of Costs

Both variable and fixed costs enter into the treatment of water. Variable costs are those which are dependent upon the quantity of production and vary with the amount produced, whereas the unit cost remains almost constant. In water treatment, three items can be considered variable: [1] labor and operators' wages; [2] chemicals required in treatment; [3] fuel and power for heating, running motors, and automatic controls.

Fixed costs are independent of the quantity of production. They are the same whether 1,000 or 10,000 units are produced. The cost per unit, however, decreases with increased production. The fixed costs of water treatment are:

1. Administrative costs, or overhead
2. Insurance on structures and equipment
3. Depreciation of structures, equipment, raw-water pipe
4. Maintenance of structures, equipment, raw-water pipe
5. Interest that is applicable to structures, equipment and raw-water pipe.

Unit Treatment Cost

In calculation of fixed and variable expenses at Cleveland, a unit of 40,000 gal is chosen for convenience. This unit is the closest to the average half-hour of the maximum hourly pumpage of 83,333 gal.

In computations of labor and power costs, the 7-day week is used because: [1] although the wage scale is based on a 40-hr week, operation is on a 7-day basis, and [2] power and electricity cost is based on hours of operation time, which is related to operators' time.

Variable Costs

Fringe benefits as well as gross pay enter into the total cost for wages,

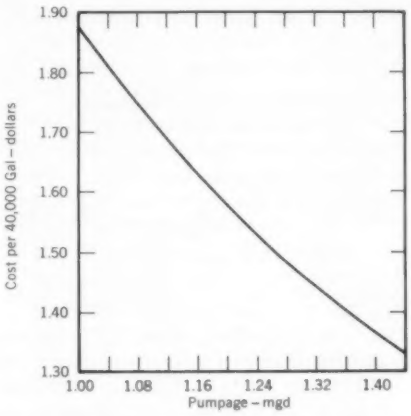

Fig. 2. Composite-Cost Curve, Waterville Springs Pumping Station

The curve represents the composite (sum of variable and fixed) costs for a demand range of 1.00–1.44 mgd.

with the exception of overtime pay. In addition to regular wages, each employee receives 80 hr paid vacation per year, 96 hr paid sick leave, and 48 hr paid holidays, for a total 224 hr paid per man per year in addition to hours worked; the utility must also pay 2.5 per cent of the gross payroll for social security tax, $2.60 per man per month for accident insurance, and $0.98 per man per month for life insurance.

If an operator's base pay is $1.56 per hour, then his total straight-time hourly rate is

($1.56 × 114 per cent) + $0.02 = $1.80.

The hourly rate for overtime is $2.34.

Correlating water pumpage with wages serves two purposes. It shows when it is more economical to put on another operator and gives the labor cost per 40,000-gal unit pumped. Such a correlation for Cleveland is given below. If the pumping demand is 0.84 mgd, the weekly demand is 0.84. × 7 = 5.88 mil gal, and the number of 40,000-gal units per week is 5,880,000 ÷ 40,000 = 147. The pumping time, then, is 5,880,000 ÷ 83,333 = 70.56 hr/wk. Straight time is 40 × $1.80 = $72.00 per week. Overtime is 30.56 × $2.34 = $71.51 per week, which is $72.00 + $71.50 = $143.51 per week for one operator. The cost per unit with one operator is $143.51 ÷ 147 = $0.9763. The labor cost per unit with two operators is, at a demand of 0.84 mgd, (80 × 1.80) ÷ 147 = $0.9799.

TABLE 1

Cost of Chemicals for Treatment at Cleveland Plant 1956–57

Chemical	Amount Used		Cost per 40,000 gal *cents*
	Averall Avg *ppm*	per 40,000 gal *lb*	
Chlorine	2.7	9.900	11.03
Fluoride	1.0	0.056	5.00
Lime	11.98	4.000	4.05
Aluminum sulfate	0.76	4.330	10.65
Total			30.73

It can be seen from these figures that the cost per unit would be somewhat higher if two operators were employed. This is true for any demand of less than 0.84 mgd. It is more practical to employ the least number of operators until such time as overtime pay for one man equals or exceeds his regular pay. For each pumpage increase of 0.37 mgd an additional operator would be justified.

As the actual operating times of both the filter plant and pumping station are known, the corresponding electric-power consumption for each month is correlated with pumping time to obtain the average number of kilowatt hours per hour of operation. The power-billing demand, defined as the maximum number of kilowatt-hours consumed in any continuous 30-min period, should remain fairly constant throughout the pumping range, because the same electrical equipment is used whether demand is 1 mgd or 2 mgd. In order to allow for a margin of safety, however, the maximum power-billing demands per month were averaged and increased 5 per cent. They average as follows: filter plant, 105 kwhr/hr at 35 per cent per month billing demand; raw water pumping station, 75 kwhr/hr at 32 per cent per month billing demand.

To compute the power cost per 40,000-gal unit at a demand of 0.84 mgd, it is necessary to find the power cost per day and divide by 21 (number of units pumped per day), as follows:

Pumping rate is 0.84 mgd, operating time is 84,000 ÷ 83,333 = 10.08 hr/day or 70.56 hr/wk, and monthly power consumption is 70.56 × 52 ÷ 12 × 105 = 32,105 kwhr. Power rates are: $0.008 per kilowatt-hour for the first

15,000 kwhr; \$0.006 per kilowatt-hour for the next 25,000 kwhr; and \$0.004 per kilowatt-hour for the next 60,000 kwhr. The billing demand constant is 320 kwhr.

$15{,}000 \times 0.008 = \$120.000$
$17{,}105 \times 0.006 = \$102.630$
Billing constant is $0.35 \times 320 \times \$1.00 = \$112.000$

The total is then $120.000 + 102.630 + 112.000 = \$334.630$.

The 10 per cent surcharge is \$33.463, and the total monthly bill is then $334.630 + 33.463 = \$368.093$, which is \$12.135 per day.

Dividing by the number of 40,000-gal units pumped per day gives $12.135 \div 21 = \$0.5778$ per unit.

When computed in the same manner, the raw-water pumping station power cost is \$0.4623 per unit. The total power expense, then, is $\$0.5778 + \$0.4623 = \$1.0401$ per 40,000-gal unit.

The average amounts of chemicals used in treatment and their costs are based on actual operating conditions (Table 1).

Total Variable Costs

The sum of the variable expenses attributed to the unit treatment cost is \$2.3237 per 40,000 gal at a demand of 0.84 mgd. In a similar manner, the cost for each increment of 40,000 gpd, from a minimum demand of 40,000 gpd to the maximum of 2 mgd, was calculated and plotted to obtain the variable expense curve shown in Fig. 1. To determine the cost per 1,000 gal at any desired pumping rate, one may simply read the value corresponding to the pumping rate and divide by 40.

Although the pumping rate is based on a 7-day work week, the unit treatment cost may be determined for any given period so long as an accurate record is kept of the pumpage for the given time.

Fixed Costs

In effect, administrative expenses are indirect costs; nevertheless, if the actual cost of production is to be determined, they must be accounted for and allocated to the various phases of operation. To determine exactly what portion of these expenses is attributable to treatment is a very difficult problem. Items classified as administrative expenses include: salaries for administrative employees; insurance on equipment, buildings, trucks; employee insurance; advertising; and miscellaneous office expenses.

The total of these expenses at the Cleveland plant is \$474.23 per week. The percentage of this total attributable to treatment cost is 5.51 per cent, as determined by the direct-labor distribution method. Thus, the amount attributable to treatment cost is $5.51 \times 474.23 = \$26.13$ per week. Cost per 40,000-gal unit at a demand of 0.84 mgd is $26.13 \div (7 \times 21) = \$0.178$.

Insurance

Only the insurance that is applicable to the filter plant and raw-water pumping station buildings and equipment is considered. This is \$550,000, at a premium of \$367.36 per year, or \$7.0646 per week. The cost per 40,000 gal based on a daily demand of 0.84 mil gal is $\$7.064 \div (7 \times 21) = \$0.0481$. The cost per 40,000-gal unit decreases as the demand increases.

Depreciation

It is essential that depreciation costs be considered so that capital may be recovered or maintained; otherwise, there will be a depletion of capital. Because capital must be maintained, it is necessary that the recovery be made by charging the depreciation that has taken place to the cost of the products produced.

There are two types of depreciation, physical and functional. Physical depreciation is mechanical deterioration and wear with the passage of time, whereas functional depreciation is the result of technical progress or unpredictable changes in method which render otherwise usable capital obsolete. Therefore, functional depreciation is very difficult to anticipate.

In applying depreciation to water treatment, the straight-line method is used, and as there is no practical way to determine what the salvage value of an item will be at the end of its useful life, it is not considered. After much research, it was found that some suppliers of water treatment facilities believe that an average life of 20 years is sufficient. Because part of the equipment at the Cleveland filter plant and raw-water pumping station will not be used for 10–15 years (that is, it can suffer only functional depreciation during this period), the assumed life of 20-years is invalid. This equipment is designed with a 6-mgd capacity, although the maximum demand now is only 2 mgd.

In Table 2 is a depreciation schedule set up in the light of conditions at Cleveland. In order to simplify the depreciation schedule, only the total depreciation is given. Each of the items was broken down into its component parts and considered carefully as to its economic life.

TABLE 2

Depreciation of Facilities and Equipment at Cleveland Plant

Item	Installed Cost $	Weighed Avg Life–yr	Annual Depreciation $
Equipment at filter plant and raw-water pumping station	234,411.00	33.67	6,664.35
Structures, heating ducts, painting, wash water tank, and wiring at filter plant and pumping station	512,507.98	54.31	9,438.01
Raw-water pipeline from pumping station to filter plant	273,368.84	100.00	2,733.68
Total	1,020,278.82		18,836.04

Applying total depreciation to unit production and assuming a 840,000-gpd demand, then the cost per 40,000 gal is $18{,}836.04 \div (52 \times 7 \times 21) = \$2.4642$.

Maintenance

All repairs, minor or major, to any portion of production facilities should be distributed to the treatment cost.

This element of cost is hard to predict, but repairs and replacement costs should be based on accurate cost records of actual operating conditions over a period of years.

As a matter of procedure, some accountants and engineers say, presumably based on similar conditions, that the maintenance cost of machinery should be 5 per cent per year of the installed cost, but they differ in their opinions on buildings, structures, and pipe. It stands to reason that in order for facilities to last as long as they are intended to, they must be kept in good working order.

An amount should be set down for maintenance of facilities, but it will have to be adjusted from time to time according to actual expense records. It is a basic fact that the older facilities become, the more maintenance they require. Many economists and engineers believe that if facilities are kept in good working order, then there is no need for a depreciation reserve. This is sometimes true, if obsolescence, efficiency, and output capacity are not major considerations.

Table 3 is a maintenance schedule for the Cleveland plant. It is as accurate as possible in the light of present data and recommendations from various authorities. As in the depreciation schedule (Table 2), each item was broken down into its component parts and carefully considered before being totaled.

The maintenance cost per 40,000 gal based on a demand of 0.84 mgd, is $11,885.08 \div (52 \times 7 \times 21) = \$1.5548$.

Interest

There is considerable difference of opinion among accountants and engineers as to the handling of interest on investment capital as a production cost. Interest, however, must be considered at some point, whether it is on borrowed capital or on reserves. If facilities are constructed from reserve capital, chances are that these reserves are earning some rate of interest and will continue to do so if not put to some other use. The same is true of borrowed capital—only more so—because the interest and proportionate capital must be paid or foreclosure is inevitable.

There are two ways of handling interest in the determination of unit production cost: [1] to include it in the production cost, or [2] to consider it as an expense item against profits at the close of the year. Because a publicly owned utility is not concerned with profits, it would appear logical to distribute the interest on treatment facilities in amounts proportionate to their cost. This would be especially true of borrowed capital or bond issues for which the entire public served is responsible. Then, if there are any profits after the interest is distributed and accounted for, in production for example, it should either go into reserve, expansion, or reduction of rates.

TABLE 3

Maintenance Schedule for Cleveland Plant

Item	Original Cost $	Annual Maintenance $
Equipment at filter plant and raw-water pumping station	234,411.00	4,591.07
Structures at filter plant and raw-water pumping station	512,507.98	5,927.17
Raw-water pipeline from pumping station to filter plant	273,368.84	1,366.84
Total	1,020,278.82	11,885.08

Once it has been determined that interest should be included as a production cost, a question arises as to the period of time over which it should be distributed—although it is the author's belief that the interest for each year, whether the payments are reduced year by year or not (as series bonds), should be included as a production cost item.

As a compromise and a means of arriving at a workable production cost, the entire bond issue for water construction is taken and distributed over the useful life of all facilities as follows:

Total depreciation per year (Table 2) is $18,836.04.

Total cost of facilities subject to depreciation is $1,020,278.82.

Weighed average (useful) life is $1,020,278.82 \div 18,836.04 = 54.17$ years.

Of the total bond issue (1954–1984), the portion applicable to water treatment is $1,037,434.92.

The total interest for 30 years, less bond premiums, is $523,486.21.

Interest per year is $523,486.21 \div 54.17 = \$9,663.77$.

The interest cost per 40,000 gal at a 0.84-mgd pumping rate is $9,663.77 \div (52 \times 7 \times 21) = \$1.2642$.

Total Fixed Costs

The sum of fixed expenses attributable to the 40,000-gal unit treatment cost is $5,6156, based on a pumping rate of 0.84 mgd. Similarly, the cost for each unit increment was determined and plotted on the fixed-expense curve shown in Fig. 1.

The interpretation of the fixed-expense curve is exactly the same as for the variable-expense curve, both of which are shown separately in Fig. 1. The cost per 1,000 gal at any pump rate can be obtained simply by reading the cost per unit corresponding to that pumping rate and dividing by 40. The fixed expenses present a smooth, uniform curve. This is because the cost per unit decreases as the demand rate increases. The smaller the demand rate, the greater the cost per unit.

Combined Cost at Filter Plant

In order to present the entire picture of treatment costs, the variable- and fixed-expense curves have been combined to obtain the composite curve also given in Fig. 1. The curve tends to smooth out when the two costs are combined, and unit cost decreases more slowly as the plant approaches its capacity. As before, the cost can be found for any desired pumping rate, and for various combination rates of pumping per day so long as the amount pumped each day for a given period of time is known.

Waterville Springs

The pumping station at Waterville Springs is operated 24 hr per day and pumps directly into the distribution system. There are two pumps which are rated at 600 gpm each, but seldom, if ever, reach that capacity because of the tremendous head under which water is being pumped. Any water consumed above the demand capacity of these pumps has to be supplemented by the filter plant. The variation in water demand also has a great deal to do with the amount of water the Waterville Springs contribute to the system. An examination of Fig. 4 reveals that demand is smallest in February (1.22 mgd) and greatest in August (1.46 mgd).

As before, the 40,000 gal unit is used in computing the fixed and variable

expenses, for convenience only. In order to simplify the computations as much as possible, only the combined expenses (fixed and variable) are graphically shown, and they range from 1 mgd to 1.44 mgd. In all expenses, the same reasoning used for computing unit treatment costs for the filter plant is used in the cost analysis per unit production at Waterville Springs.

Variable Costs

Only two men are required to operate Waterville pumping station, for three reasons: [1] the clear wells are covered and the entire area is enclosed by a woven-wire fence; [2] there is a battery-operated, automatic alarm system attached to the pumps which warns the operator in case of failure; and [3] two chlorinators operate simultaneously, each feeding half of the required amount of chlorine, so that if one fails the water will not be entirely without treatment. Because of these precautions, the night operator is not required to stay on duty. With all fringe benefits included, the total labor cost per day is \$15.506. If 1,320 gpd is pumped, the cost per 40,000 gal is $15.506 \div 33 = \$0.4699$.

TABLE 4

Quantities and Cost of Chemicals Used in Treatment, Waterville Springs

Item	Amount Used *ppm*	Cost per 40,000 gal *$*
Chlorine	0.7	0.0286
Fluoride	1.0	0.0513
Total		0.0799

Only chlorination and fluoridation are used in treatment at Waterville Springs. Table 4 gives cost data for the chemicals used.

Based on actual power operating cost over a 2-year period, it has been noted that the power consumed is almost directly proportional to the head overcome. If demand is small, the pumps build up a head and pump against this head, thereby increasing the power consumed. As the number of hours operated is constant the high side of the average number of kilowatt hours consumed per hour of operation is used to obtain an adequate workable cost figure. The average power cost is \$13.209 per day. If demand is 1.32 mgd, the cost per 40,000 gal is $13.209 \div 33 = \$0.4003$.

Total variable cost per unit at Waterville Springs at a 1.32-mgd pumping rate is \$0.9501.

Fixed Costs

Overhead expenses are distributed by the use of the direct-labor method to unit production as stated below.

The total administrative cost per week is \$474.23.

The percentage of operators' wages applied to administration is 2.59 per cent, and the amount, then, is $2.59 \times 474.23 = \$12.28$ per week.

If the demand is 1.32 mgd, the cost per 40,000 gal is $12.28 \div (7 \times 33) = \$0.0532$.

The insurance premium on the buildings and contents is \$43.89 per year or \$0.1206 per day. At a daily demand of 1.32 mgd, the cost per 40,000 gal is $0.1206 \div 33 = \$0.0037$.

It was difficult to determine the exact cost of the Waterville pumping station; however, it is believed that a reasonably close estimate was obtained by consulting various costs reports for similar structures and equipment, then

checking the results against available records on its actual construction costs. The cost and depreciation were found to be $52,454.25 and $1,616.61, respectively. The cost per 40,000 gal based on a demand of 1.32 mgd is 1,616.61 ÷ (52 × 7 × 33) = $0.1346.

able cost. The annual maintenance cost is $1,811.24. The cost per 40,000 gal based on a demand of 1.32 mgd is 1,811.24 ÷ (52 × 7 × 33) = $0.1508.

The total investment in the Waterville pumping station was $54,954.25, including land and rights-of-way. As

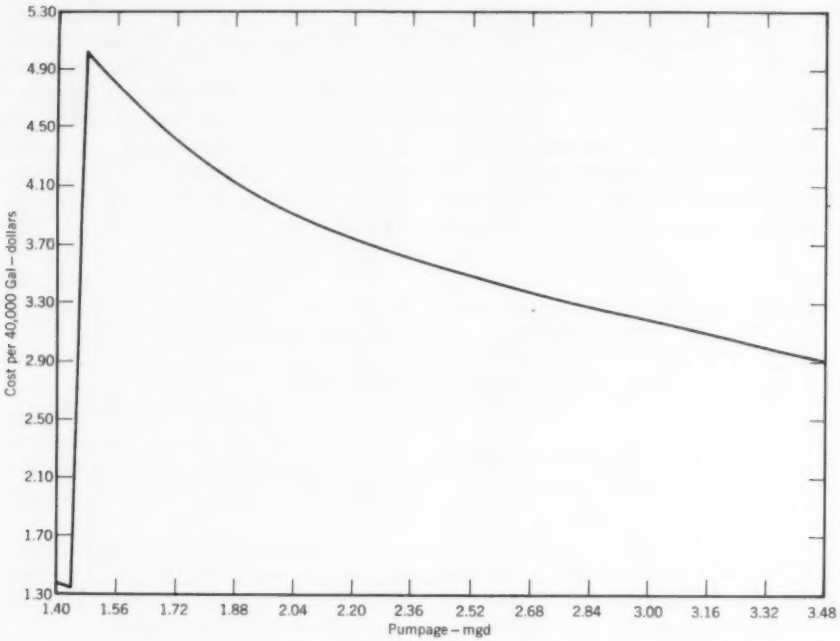

Fig. 3. Total Combined-Cost Curve, Waterville Springs and Filtration Plant

The curve represents combined costs for a demand range of 1.40–3.44 mgd. The portion of the curve before the lower peak (at 1.44 mgd) represents the cost at Waterville Springs alone; the upper peak (at 1.48 mgd) represents the total cost at the initial starting of the filtration plant.

The maintenance cost is computed for Waterville in almost the same way as for the filter plant, but there is a time lapse between construction date and the present. Some of the maintenance cost is known, and is taken into consideration in determining a work-

it has already been decided to include interest on bond issues, it is consistent to include it in all other cost phases. Considering an interest rate of 3½ per cent, the annual interest is 0.035 × 54,954.25 = $1,923.40. If the same procedure is followed as for interest

on bonds for the filter plant, this will run for 30 years. The weighed average life of pumping station buildings and equipment is 52,454.25 ÷ 1,616.51 = 32.45 years. The weighed average interest per year then is (1,923.40 × 30) ÷ 32.45 = \$1,778.18. The interest applied to water treatment cost per 40,000 gal at a demand rate of 1.32 mgd is 1,778.18 ÷ (52 × 7 × 33) = \$0.1480.

Total Cost

The total cost, both fixed and variable expenses as outlined earlier per 40,000 gal at a pumping rate of 1.32 mgd is \$1.4404. For Fig. 2 the same procedure is followed to obtain the cost in increments of 40,000 gal, beginning at a demand or pumping rate of 1.00–1.44 mgd, as in Fig. 1.

Total Combined Costs

Because each of the sources of supply furnished a portion of the total water demand, it is desirable to know the combined-average unit cost from present demands projected forward to the ultimate capacity. This information is shown in Fig. 3 representing the combined cost of both sources of supply from a demand of 1.44 mgd to the ultimate capacity of 3.44 mgd.

In the computations for this curve, it was assumed that Waterville furnished 1.44 mgd of the total demand; this was done in order to obtain costs at the maximum capacity for future planning in plant expansion. This assumption will not always hold true, however, because Waterville pumpage will not always be at this rate. Values for the combined-cost curve in Fig. 3 were obtained as follows:

If a demand of 2.2 mgd (55 40,000-gal units) is assumed, and if Waterville supplies 1.44 mgd (36 units), then the filter plant supplies 0.76 mgd (19 units). The costs per unit supplied at this demand by Waterville and the filter plant, respectively, are (from Fig. 1 and 2) \$1.33 and \$8.42. The total cost, then, is (36 × 1.33) + (19 × 8.42) = \$207.86 for 55 units.

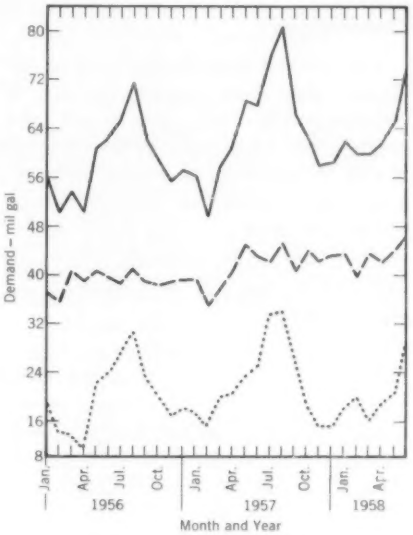

Fig. 4. Demand Variation from January 1956 to July 1958

The dotted and broken curves represent demands of the filtration plant and Waterville Springs Pumping Station, respectively. The solid curve is for the combined demand at both installations.

Average cost per unit is 207.86 ÷ 55 = \$3.78; for 1,000 gal the cost is 3.78 ÷ 40 = \$0.095. Similarly, all costs were determined in increments of 40,000 gal to obtain a graphic relationship of various stages of demand to ultimate capacity.

To give some idea of the demands on the Cleveland water system, a graph has been prepared showing the monthly pumpage from each source of supply, beginning with January 1956 and ending June 1958. Each source is shown separately and then all are combined to show both low and high peak demands (Fig. 4).

Conclusions

One of the first things that an industry does is to compute the cost of producing what it is going to sell. An attempt has been made here to present a way in which to determine, as accurately as possible, the cost of treating water, the product of the water utility. Among the many ways in which this knowledge can aid management are that it can:

1. Indicate what effect large consumers or industries will have on the overall costs (to increase the demand means to decrease the unit production cost)
2. Aid in determining when and how much treatment facilities should be expanded
3. Aid in setting rates, particularly where large consumers are involved
4. Serve as a guide for future record-keeping and accounting purposes
5. Help to determine the cost of serving each consumer, so that the utility can evaluate its rate structure and determine how much can be invested in main extension to obtain an additional consumer
6. Aid in setting up an aggressive construction and preventive-maintenance program in place of a merely corrective one.

Occurrence of a Nematode Worm in a City Water Supply

Shih Lu Chang, John H. Austin, H. Wallace Poston, and Richard L. Woodward

A contribution to the Journal by Shih Lu Chang, Sr. Surgeon, John J. Austin, San. Engr., H. Wallace Poston, San. Engr. Director, and Richard L. Woodward, Chief, Water Supply, all of the Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

DURING the development of a procedure in May 1955 for the detection of *Endameba histolytica* cysts in water (*1*) by the membrane filter technique, concentrates of treated Ohio River tap water were found to contain motile nematode larvae of microscopic size. Examinations of tap water collected at different parts of the city * revealed that these larvae were present in the entire distribution system. The examination was continued for 4 months and the larvae were persistently found, mostly alive, at densities of 1–20 per gallon, except on one occasion when as many as 100 larvae per gallon were detected.

It is of particular interest that these nematode larvae as well as the experimental ameba cysts remained viable for at least 100 min in a hypochlorite solution containing 1.8–2.4 ppm free residual chlorine at a pH of 8.3–8.4 (*1*).

With the cooperation of the superintendent of the filtration plant, a nematode survey was conducted at the plant in a search for the source of infestation. Results gathered in a 5-month period suggested that these larvae might come from the raw water and from breeding places in the sedimentation basins and rapid sand filters. Subsequent examinations of scrapings from walls of the sedimentation basin and of sand removed from different depths of the filters failed to yield any evidence of worm breeding, however.

In March–May 1956, periodic examinations of the tap water and of the raw, chlorinated raw, flocculated and settled, and filtered waters made at the filtration plant showed persistent presence of the same nematode larvae in small numbers. During the latter part of May and early part of June, a sudden increase in worm population was observed in various samples from the distribution system and the plant. An intensive survey was immediately started. Attempts were also made to identify and cultivate the worms on artificial media and to test their resistance to common water disinfectants.

Treatment at Filtration Plant

Normal treatment of the raw water is as follows: the water is chlorinated to a free residual of 1 ppm or more and settled in basins, which provide approximately 2 days' detention. About 10 ppm of alum is frequently added prior to sedimentation. The water is then flocculated with about

* Name of city withheld by request.

10 ppm of ferric sulfate, settled, and filtered. Activated carbon is added prior to the second flocculation and chlorine, when needed, is added to maintain a residual of 0.75–1.00 ppm at the filters. Anhydrous ammonia is finally added to convert the free residual chlorine to a combined residual chlorine before the water enters the distribution system.

Nematode Survey

Plant samples were collected in gallon jugs each morning from continuously running taps in the laboratory at the filtration plant. Distribution system samples were collected from a tap located about 3 mi from the filtration plant.

TABLE 1

Sample Volumes for Concentration

Sample Type	Amount Filtered *gal*
Raw river water	0.065–0.130
Chlorinated raw water	0.026–0.130
Flocculated and settled water	0.390–0.780
Filter influent	0.515–1.000
Filter effluent	1.000
Tap water	1.300–2.600

Method of Examination

Samples were concentrated by the membrane filter technique described in a previous report (*1*). The size of the samples was dictated by the amount of suspended solids present. Table 1 shows the volumes used. Volumes were chosen which could be filtered within 1 hr.

As the last of the water sample was disappearing from the membrane, the suction line was disconnected and the membrane was transferred onto the inner side of a 50–100-ml beaker. The membrane surface was repeatedly flushed with 1–2 ml distilled water, which was finally pipetted into a Sedgwick-Rafter counting chamber and examined under a microscope. The numbers of live and dead nematodes in the concentrate were counted. Dead nematodes were recognized by their lack of motility and the granular appearance of that part of the body which is transparent in live individuals. Any worms that differed morphologically from those normally encountered were noted.

Results and Analyses

Results of the microscopic counts of worms in various samples examined during this period are summarized in Table 2. An examination of this table reveals several points of significance. First, during the 16 days prior to Jun. 22, there was a general correlation in the relatively low worm population between the raw and chlorinated raw water samples, which suggested that the river was a source of infestation. The larger number of live worms in the raw water as compared to the larger number of dead in the chlorinated raw water in most samples reflected a definite lethal effect of the free residual chlorine on at least some of the worms. The small number of worms found in samples from subsequent stages of treatment indicated that most of the live as well as the dead individuals were settled out in the flocculation basin.

Second, on Jun. 22, although the raw water showed no great increase in live-worm population, in the chlorinated raw water there was a tremendous increase in live worms and a much smaller increase in dead ones. It is also interesting that, although worms found prior to that date had practically all been in the larval stage, adults were encountered in this huge worm popu-

lation. On Jun. 23 there was a slight increase in live-worm population in the raw water and a 75 per cent population decrease in the chlorinated raw water. During the following 13 days, the raw-water live-worm density varied from 23 to 124 worms per gallon, whereas the density in the chlorinated raw water tapered off from 246 to none per gallon and was accompanied by the occurrence of large numbers of the following 3 days. The greater number of dead worms over the live found on Jun. 24 as compared to the greater number of live to dead worms on Jun. 23 and 25 clearly indicates that 8.2 ppm initial chlorine was more effective in killing worms than 7.0 ppm.

Third, despite the large increase in the worm population in the chlorinated raw water, there was only very slight increase in the flocculated and settled

TABLE 2

Occurrence of Nematode in Ohio River Water Samples, June–July 1956*

Date	Number of Worms per Gallon											
	Dead						Alive					
	R	C	FS	I	E	T	R	C	FS	I	E	T
Jun. 6	0	8	8	1	1	—	8	0	8	1	1	—
8	23	8	8	0	2	1	77	0	3	0	1	1
11	0	39	1	0	0	3	23	8	0	0	0	2
12	15	15	4	0	0	1	0	15	0	0	0	1
14	0	8	4	0	0	1	15	0	4	0	3	1
15	8	0	2	1	0	0	77†	15	2	0	0	1
18	0	8	0	0	0	1	8	0	0	0	0	0
20	0	0	0	0	0	1	8	0	0	0	0	0
22	0	54	6	1	1	0	70†	1,080†	4	2	1	1
23	8	31	3	0	1	0	100†	262†	13	6	4	1
24	23	318	13	0	0	0	23	246†	3	2	7	1
25	0	116	0	1	0	1	39	155†	13	3	2	2
27	8	242	18	1	1	1	62	31	10	1	1	3
29	0	47	8	1	1	1	124	31	0	1	1	1
Jul. 2	23	124	15	—	—	0	70	78	13	—	—	1
6	0	0	3	—	—	0	46	0	0	—	—	0

* Code designations are: R, raw water; C, chlorinated; FS, flocculated and settled; I, filter influent; E, filter effluent; and T, tap water.
† Including a few adults.

dead worms. The explanation of this phenomenon is that probably a large number of egg-bearing females settled in the pipeline or sample tap line and the eggs subsequently hatched.

The chlorine applied to the raw water on Jun. 22 was 6.6 ppm. As a result of the appearance of a large worm population, the dosage was increased to 7.0, 8.2, and 7.0 ppm on water and even less in the filter influent. It appeared then that most of both the live and the dead worms were settled out in the flocculation basin. It should be noted that the worms found in the filter influent and effluent and in the tap water were practically all larval forms without sheaths. On account of their small size they apparently failed to settle in the flocculation

basin and were carried into the distribution system.

Fourth, the lack of any significant difference in worm density between the filter influent and effluent indicates that the rapid sand filters were ineffective in removing these larval worms and rules out the possibility that the worms were bred in the filters.

Identification of Worms

A small number of larval worms collected in 1955 were examined by G. Steiner, head nematologist of the Horticultural Corps Research Branch, US Department of Agriculture, who assigned most of the worms to the genus *Monhystera*. A rare one was identified as an undescribed species of *Seinura*.

During the 1956 survey, further attempts were made to identify the worms collected in the chlorinated raw water, as well as to cultivate them on artificial media. On the basis of the morphological characteristics observed in the small number of adult worms collected and in large numbers of adults obtained in cultures, the genus *Monhystera* was confirmed for only a small minority of them. A culture of the worm most commonly found was sent to Steiner and it was identified as *Diplogaster nudicapitatus* (Steiner, 1914). The unidentified species of *Seinura* was again encountered in the 1956 survey but not identified further.

Biological Features of Worm

Although the morphology and nomenclature of *Diplogaster nudicapitatus* will be described separately by Steiner, and the cultivation, life cycle, and resistance to free residual chlorine will be presented in detail in two subsequent reports (*2, 3*), a brief description is given here to provide water utility engineers and biologists with a general knowledge of this nematode.

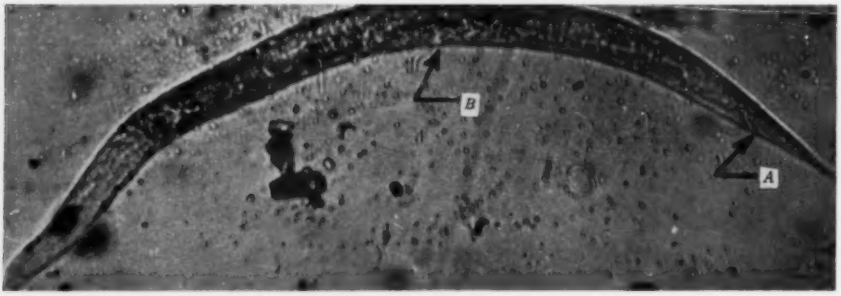

Fig. 1. Female *Diplogaster nudicapitatus*

The female is 0.8–1.05 mm long and 0.05–0.06 mm wide at its greatest breadth. Points A *and* B *are, respectively, anus and genital pore. The microphotograph is approximately 155 ×.*

The body of the worm is plump and tapers anteriorly to a rather broad head. The cuticle has many longitudinal striations. The female is 0.8–1.05 mm long and is 0.05–0.06 mm wide at the greatest breadth, with a long tail which tapers to a whiplike end. The genital pore is located a little posterior to the middle of the body and the anus is subterminally located. These two locations are shown in Fig. 1. The larvae are 200–300 μ by 10–30 μ.

The male is about three-fourths the size of the female. The posterior end

tapers abruptly into the whiplike tail. A pair of ventrally arcuate spicules is subterminally located, leading internally to a knobbed gubernaculum. These features are indicated in Fig. 2. The worm also has nine pairs of caudal papillae, which are visible only through phase-contrast microscopy.

The fertilized eggs generally hatch out within the female while it is still alive. The larvae feed on the body content of the mother worm and are released to the outside when the cuticle undergoes disintegration. Maturation takes place after four moltings, in each of which a sheath is shed. In cultures on artificial media, eggs are frequently voided by the females and hatch outside.

Although a culture of this worm was maintained for at least 8 months in a flask of Ohio River water containing a large amount of sediment concentrated from the same river water, the growth was very poor. Addition of nutrient to such a culture invariably resulted in death of the worms, due apparently to the partial anaerobiosis created by the rich bacterial growth. This is believed to be the explanation for the failures in growing this worm on fluid media. On agar plates, however, a rich growth can be maintained indefinitely in association with *Proteus mirabilis* or *Aer. aerogenes*. Both the larvae and the adults of this worm feed freely on cells of these bacteria and flourish in the mucoid material they produce.

The sheathed larvae are more resistant to free residual chlorine than the adults, which are, in turn, more resistant than the nonsheathed larvae. The eggs are the most resistant, however, especially those still lodged inside the females. It appears the resistance to HOCl depends on the degree of protection offered by the sheath or egg shell. As will be reported later (*3*), even the nonsheathed larvae are not all killed by 3–5 ppm free residual chlorine at 24–25°C and pH 7.0–7.2 until contact time exceeds 3 hr. This amazingly high resistance to free residual chlorine serves to explain the presence of living larvae in the distribution system and their survival with a 1.8–2.4-ppm chlorine residual and at pH 8.3–8.4 in the cyst detection experiment.

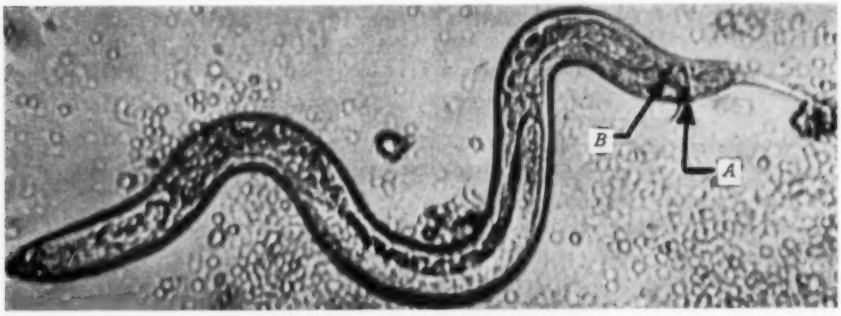

Fig. 2. Male *Diplogaster nudicapitatus*

The male is approximately three-fourths as large as the female. Points A *and* B *are, respectively, paired spicules and gubernaculum. The microphotograph is approximately 300 ×.*

Discussion

The occurrence of bristle (*Nais*) worms has been reported recently in swimming pools and filters in Germany (*4*), and *Nais*, a nematode (*Trilobus gracilis*), and a trematode (*Stenostomum*) have occurred in a public water supply in England (*5*). Although the *Monhystera* worm was frequently found in large numbers in the raw water of the Chanute, Kan., water supply, it was detected in small numbers only once in the finished water in a zoological survey of the water supply during emergency use of reclaimed water (*6*). It is believed that this is the first report on the persistent occurrence of the phasmid nematode, *Diplogaster nudicapitatus*, in a relatively large municipal water supply.

The frequent presence of live and dead *Diplogaster* larvae and adults in the raw river water provides sufficient ground for the belief that the river was the primary source of the infestation in the filtration plant and that the onset of a large worm population in the chlorinated raw water during the latter part of June was a result of breeding in the pipeline or the sample line. Evidently, under normal conditions, most of the relatively small number of larvae carried in the river water are destroyed by the free residual chlorine or removed by flocculation and sedimentation, and very few are left in the finished water. When large numbers of worms were carried in the river water, the female worms survived the chlorination and settled to the bottom of the raw-water pipeline or the sample line, causing the temporary increase in the worm population.

Of particular significance in the occurence of the nematode in a water supply is the fact, to be reported in the third paper of this series (*3*), that larvae and adults can ingest pathogens, such as *Salmonella*, *Shigella*, and Coxsackie A9 virus, and protect them from the destructive action of free residual chlorine.

Summary

There was a persistent occurrence of the nematode, *Diplogaster nudicapitatus*, in a city water supply using Ohio River water for a period of at least 14 months, and unusually large numbers of live and dead worms occurred in the chlorinated raw water for 4 days toward the end of the period. From the evidence gathered, it is believed that the raw river water was the source of infestation and that the onset of large numbers of worms in the chlorinated raw water was caused by hatching of eggs in female worms that had settled in the pipeline. The high resistance of the adults and eggs of this worm to free residual chlorine is blamed for this accidental breeding.

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Conversion From Slow to Rapid Sand Filtration at Wilmington

Miriam S. Shane

A paper presented on Oct. 31, 1958, at the Chesapeake Section Meeting, Wilmington, Del., by Miriam S. Shane, Director of Labs., Board of Water Comrs., Wilmington, Del.

UNTIL the fall of 1953 the high service in Wilmington was supplied by a slow sand filter plant which was placed in operation in 1909. Water from Brandywine Creek was pumped to the 35-mil gal Porter Reservoir located about 2 mi from and elevated some 250 ft above the pumping station. The finished water from the filter plant clear well flowed back to the city by gravity.

Old Plant

The plant consisted of six slow sand filter beds, each with an area of ¼ acre. These beds were washed and raked by an electrically operated machine which ran on tracks—one of a limited number manufactured. There was no pretreatment of the raw water other than a 3-day or longer retention period in the Porter Reservoir; postchlorination was practiced as the water left the clear well. This plant could not handle high turbidities and when the turbidity in the creek exceeded 250 ppm, pumping to the reservoir was stopped. Because of the 3-day retention period, waters of turbidities of more than 30 ppm were seldom applied to the beds. This, of course, was a great handicap during storm periods. As a result, a 6-mgd, turbine-driven, centrifugal pump was installed to deliver water from the Brandywine Rapid Sand Filter Plant directly to the high-service distribution system and augment this supply. The emergency storage at the 2.2-bil gal Hoopes Reservoir could also be used during extended periods of turbidity. Problems of air binding were experienced in the winter, and algae problems could have arisen in the summer; however, a close control of algae growth was maintained by copper sulfate treatment of the reservoir.

As the consumption increased on this service, all of the problems were magnified, as is always true when a plant operates beyond its normal capacity. Fortunately, however, the finished product from this plant was of extremely high quality. The water was soft and noncorrosive to the distribution system, even though the pH ranged from 7.0 to 7.3. The water was always free of taste and odor and the bacterial count was surprisingly low even before chlorination, regardless of raw load. For those who live in these days of disinfection by chlorination, it may be hard to picture the effectiveness of slow sand filters, when operated according to design, in the removal of the coliform organisms and, in turn, intestinal pathogens.

Increased consumption had posed many operational problems in this

plant, but the consumer was receiving a water of high quality, and complaints were negligible; on very rare occasions minor chlorine complaints were registered.

With the demolition of the slow sand filter plant at Wilmington, an era seemed to pass out of the picture. Consumption grew in leaps and bounds as it did in all water plants across the country, and that feeling of confidence in the quantity and quality with the least expenditure of money and effort went with it. A new era of water consumption was ushered in with all sorts of innovations in the use of water, and new problems in its production.

New Plant

In the fall of 1953 the Porter Filtration Plant was completed and placed in operation. This plant was equipped with eight rapid sand filters, four flocculators, and all the equipment that goes with a modern rapid sand filtration plant. Plant personnel moved over to the new plant with enthusiasm, confident that all operational problems were solved. No longer would turbidities be of concern; no longer would consumption be a problem. The chlorine complaint problem would be solved because the clear well from the slow sand filter plant had been retained and some 6 mil gal of finished-water storage was available, chlorine being added as the water entered the clear well.

The operation of the two plants—that is, the old, slow sand filter and the new, rapid sand filter—was overlapped, and demolition of the old plant did not take place until everyone was satisfied that the new plant was ready to take over the load. At that point enthusiasm was exceeded only by naivete. W. Compton Wills, the water department manager and chief engineer, shared the enthusiasm, but it was tempered slightly by his wide experience; he knew full well that there would be problems—and there were.

Taste and Odor

One of the first major problems was taste and odor; this problem started immediately and lasted for 3 months. It was experienced throughout the distribution system and was of a musty, woody nature. The filtered water had neither taste nor odor as it left the plant but developed both in the distribution system, and by the time the water reached the periphery of the system it was quite bad. Neither microscopic, nor bacterial, nor chemical analyses brought any cause to light. It was known, however, that a chemically treated rapid sand filter water was being carried by a distribution system that had been stabilized by a nontreated slow sand filter water. The department was swamped with complaints and it was not easy to explain away the taste to once-contented customers.

Color

The next major problem was yellow water; complaints became epidemic, primarily from customers on 4-in. and smaller mains. Postlime treatment was started with an adjustment to the pH of the original slow sand filter water, and it was necessary gradually to boost the pH to its present 8.0–8.3. Stabilization seems to have been achieved in most areas; however, some isolated complaints still come in when the water temperature rises in the spring of the year.

During this period of taste, odor, and iron pickup, several unfortunate phenol pollutions were experienced in the raw-water supply of Wilmington—namely, Brandywine Creek. Also, during the

first summer of operation, the Wilmington area experienced a serious drought during which consumption skyrocketed. In the 5 years of operation there have been two serious drought years; one was the worst ever recorded in this area. These added to the headaches of operation, and, after enjoying wonderful consumer relations for so many years, some of the laboratory personnel were nearly developing an inferiority complex as a result of consumer complaints. The laboratory personnel have become experts on bleaching of discolored laundry and it is not unusual for them to receive a request from housewives using other water supplies for some of their chemical.

Even today, after 5 years of operaton and delivering a fine-quality water, it is not unusual to hear customers talk about the old days when Wilmington water was the very best, and how much better it was with the chlorine taste. These problems were discouraging because they involved the consuming public, and, as everyone in the water supply industry knows, even after a problem has been solved, it is not forgotten; with any flavor change or service interruption one is immediately reminded of past inconveniences.

Treatment Problems

Operational problems were also many and varied. These problems are probably not different from those experienced in any new plant, but they were worked out by Wilmington's own experience—and, it is felt, satisfactorily so.

Flocculators

The erratic results of the operation of the flocculators were of much concern. When conditions were absolutely ideal, the water applied to the filters carried a turbidity of less than 5 and, of course, during these periods it was not unusual to have filter runs as long as 125 hr. Settling of the floc was affected by wind, ice, low turbidity, turbulence during changing rate, algae, and so on. Little technical information concerning these problems seemed to be available and operations were therefore carried on according to the manufacturer's literature.

It was possible to have perfect settling, and then, within minutes after the onset of a storm accompanied by wind, to have all the basins completely churned up, the previously settled alum flow over the weirs to the filters, and an immediate rise in loss of head. This could be caused by changes of temperature between the heat of the day and the cool of the evening—usually when the temperature change was $\pm 15°F$ or more. In the morning the beds would be filled with turbid water but would clear up rapidly with no change in treatment. Ice would form a disc on the outside chamber of the basin and act as a plunger, preventing settling. Often the sludge blanket was at the top of the basin and the bottom section had perfectly clear water. This problem was successfully solved by stopping both the flocculator and the rake and running the equipment intermittently. After further experimentation, the rake and flocculator were separated so that they could be run independently. This was not recommended by the manufacturer, but it solved a great many settling problems. During certain periods operating the rake or the flocculator independently will bring about settling. Sometimes both rake and flocculator are stopped.

Algae and Crustacea

Algae were never too much of a problem in the operation of the slow

sand filter plant; the water was treated routinely with copper sulfate, and, because the reservoir was well stocked with fish, crustacea were no problem. Because of the increased consumption, many of the fish were pulled into the intake and destroyed by chlorine in the basins. Crustacea, such as *Cyclops* and *Daphnia*, multiplied and would almost completely clog the filters, particularly at night. Because microscopic examination of the water did not show high algae counts at the time, no one was aware of the problem. When a filter was drained and examined, the sand surface was found to be completely covered with what had the appearance of cooked rice grains. Microscopic examination revealed *Daphnia* in great abundance. It was also found that copper sulfate had lost much of its effectiveness because of the great reduction in retention time. Sometimes filter runs were reduced to 10 hr or less during the times of greatest need. Algae also interfered with settling; the alum floc would entrap algae, settle, and, in the course of algal respiration, float to the top of the basin with the released gas. This problem was handled by the restoration and protection of fish in the reservoir.

This past summer, starting in May, activated carbon was added to the suction line of the raw-water pumps supplying Porter Reservoir. The activated-carbon dosage averaged about 2 ppm and was very effective in reducing sunlight in the reservoir. This treatment was continued until the middle of September. The algae counts were very effectively reduced with a resultant reduction in necessary prechlorination, alum, and copper sulfate. The filter runs did not fall below 35 hr during periods of clear water and ran as long as 85 hr. Such long runs had never been recorded in this plant during the summer before.

The weather this past summer has been less favorable to algae reproduction; however, the activated carbon has certainly been a factor in increasing the filter runs during periods of sunshine and has aided both in settling of the floc and in taste and odor removal. The author feels that it has a bright future for use in this reservoir for algae control.

Conclusion

The solution of these problems—and many more, which have not been discussed—has widened Wilmington's experience horizon and brought a real appreciation of the Porter Filtration Plant. Once again, the water department is in the good graces of its consumers, whose confidence is most gratifying.

The Porter Filtration Plant is a fine plant, of which the department is very proud; it will deliver a fine-quality water, and an extensive expansion program is under design.

Ion-Exchange Treatment at High Flow Rates

Arthur W. Fynsk

A paper presented on Oct. 29, 1958, at the Chesapeake Section Meeting, Wilmington, Del., by Arthur W. Fynsk, Engr., Eng. Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.

IN recent years, the demand for specially conditioned water has been increasing rapidly. This increasing demand, combined with an equally rapid increase in the cost of equipment and materials, has created a broad interest in practical ways and means of obtaining additional capacity from existing as well as new water-conditioning equipment.

It is well known that much progress has been made during the past 10 years on the operation of rapid sand filters at flow rates higher than the customary 2 gpm/sq ft. This article will review the progress that has been made with increases in the operating flow rate of ion-exchange equipment in such typical applications as water softening and demineralization. Included in this review will be a description of long-term field tests of a two-bed demineralization system operated at flow rates of more than four times the original design rate.

The operating experience to be described is that of water demineralization, which is primarily an industrial water-conditioning application. Nevertheless, the principles involved are equally applicable to water softening by ion exchange. The latter method of water conditioning is widely practiced in both the domestic and the industrial water supply fields.

Background

For many years, operating flow rates for water-softening equipment were limited to 3–4 gpm/sq ft, because of the low capacities and reaction rates of the earlier ion-exchange materials. When the high-capacity, styrene base resins became commercially available in the late 1940's, however, operating flow rates began to increase significantly. By 1953, according to Thompson and McGarvey (*1*), 10 gpm/sq ft was considered within the limits of good engineering practice in many water-softening applications. At the present time, rates of 6–10 gpm/sq ft are most commonly used.

Actually, tests have shown that the modern high-capacity, cation resins will perform effectively in water softening at much higher flow rates. In 1950, Lindsay (*2*) reported that these materials were used successfully to soften water at flow rates higher than 20 gpm/sq ft. At the higher flow rates, however, the operating capacity of the resins was less. In other words, the number of gallons of water of a given inlet quality per operating cycle decreased as the flow rate increased. More recently, Dickinson, Benezra, and Abrams (*3*) demonstrated by laboratory tests that the high-capacity resins will soften water effectively at flow rates as high as 45 gpm/sq ft.

Their results also showed reduced operating capacity at the higher flow rates.

The operation and performance of demineralization systems at high flow rates has been investigated to a limited degree. In 1954, Caddell and Moison (*4*) showed that laboratory columns of mixed high-capacity cation and anion resins could be operated at flow rates of 5–100 gpm/sq ft without affecting the operating capacity of the resin or the quality of the water produced.

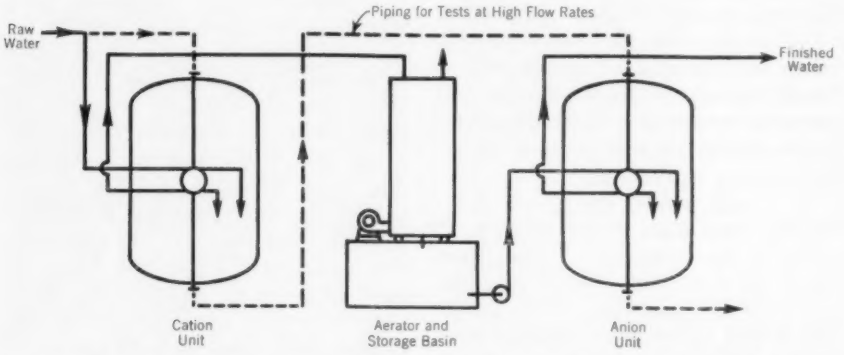

Fig. 1. Schematic Arrangement of Equipment for Tests at High Flow Rates

Dashed lines represent temporary external piping used to reduce external pressure losses, thereby making higher flow rates possible. During such tests the aerator was bypassed.

Recently, Sisson, Reid, and Frazer (*5*) described pilot plant tests of the demineralization of condensate at high flow rates for an atomic, boiling-water reactor. The pilot mixed-bed unit was operated successfully at flow rates as high as 70 gpm/sq ft. Also recently, Dickinson, Schonian, and Abrams (*6*) described laboratory tests of the demineralization of condensate from a boiling-water reactor. Their work included an investigation of pressure losses as well as the removal of minute quantities of minerals. They concluded that flow rates up to at least 100 gpm/sq ft can be used to decontaminate boiling-water reactor condensate without experiencing excessive pressure losses.

The experience reported in the literature concerning operation of demineralizers at high flow rates has been limited to the mixed-bed type of system. Although this experience is promising, it cannot be directly applied to the performance of a two-bed system, because the latter is inherently incapable of doing as complete a removal job as that done by the mixed-bed system.

E. I. du Pont de Nemours and Co. has approximately 30 demineralizer systems in service, of which 24 are two-bed systems. This represents a sizeable investment. Any significant increase in output that could be realized from the installed systems would reduce the investment required for expansion projects. Likewise, the initial investment for new facilities would be decreased.

Because of the popularity of two-bed systems and the lack of any data on them comparable to that available for the mixed-bed system, laboratory and long-term plant scale tests on this type of system were undertaken. The experiences and information derived from this work are summarized in this article.

Laboratory Tests

Initial tests were conducted by O'Hern (*7*) on 2-in. diameter columns at the du Pont Engineering Research Laboratory. The exchange materials tested were a styrene polyvinyl cation resin,* and a quaternary amine polystyrene anion resin.† The columns were operated at flow rates of 5 and 25 gpm/sq ft using Wilmington, Del., city water as the feed.

The results of these tests showed that at the higher flow rate there was no sacrifice in water quality and less than a 10-per cent reduction in operating capacity. These results were sufficiently attractive to warrant full-scale, long-term, field testing.

Long-Term Field Tests

The plant units chosen for the long-term tests were standard demineralizers which had been placed in operation in 1952. Figure 1 shows the basic arrangement of these units. Both the cation and anion units were originally designed for an operating flow rate of 120 gpm, which is equivalent to 6 gpm/sq ft for the 5-ft diameter tanks. The two exchange materials used in the units were sulfonated coal ‡ and a quaternary amine polystyrene anion resin.§

For preliminary testing, temporary external piping was installed to reduce external pressure losses and thereby enable operation at higher flow rates. This external piping is indicated in Fig. 1 by the dashed lines. To simplify operations during the tests the degasifier was bypassed. This has no effect on the test aims or results.

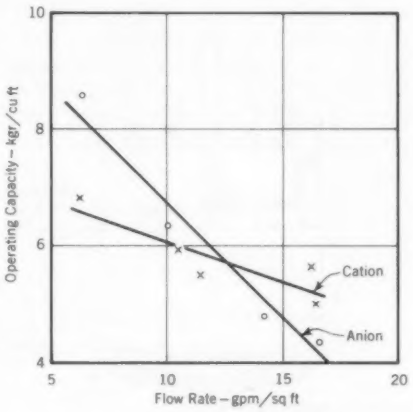

Fig. 2. Operating Capacity of Exchange Units

In the range tested, there was, as can be seen, a significant reduction in operating capacity at higher flow rates, although the quality of the finished water remained constant.

No internal changes to the units were made for the preliminary tests. As a result, the flow restriction of the internal distributors and collectors limited the maximum flow rate to 16 gpm/sq ft at the available line pressure.

The units were operated at flow rates varying from 6 to 16 gpm/sq ft. Water of equal quality was produced

* Permutit Q; a product of the Permutit Co., New York, N.Y.

† Permutit S-1, Type I; a product of the Permutit Co., New York, N.Y.

‡ Zeo-Karb; a product of the Permutit Co., New York, N.Y.

§ Permutit S-2, Type II; a product of the Permutit Co., New York, N.Y.

at all flow rates; however, a significant reduction in operating capacity occurred at the higher rates. Figure 2 shows that the operating capacities of the cation and anion units were 5.3 and 4.3 kgr/cu ft at 16 gpm/sq ft. These capacities are 25 and 50 per cent less, respectively, than the capacities at 6 gpm/sq ft.

The high loss of operating capacity was caused primarily by excessive turbulence and uneven flow distribution in the units. This was the result of using the original internal distributors and collectors at flow rates higher than those for which they were designed. Evidence of excessive turbulence was found during an internal inspection of the units following a test run at 16 gpm/sq ft. Each bed of exchange material was raised at the center and outer edges as much as 12 in. higher than the remainder of the bed surface. This resulted in an effective bed depth of approximately 75 per cent of the design depth of 30 in.

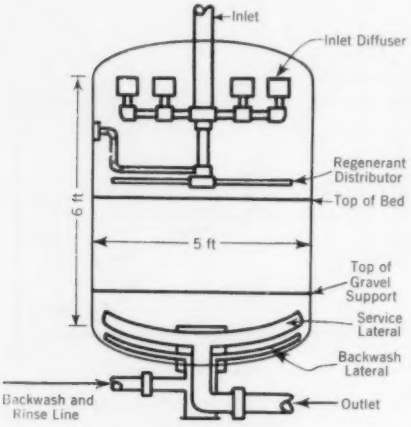

Fig. 3. Internal Assembly of Exchange Unit for High Flow Rates

The upper and lower laterals were used for high and low flow rates, respectively.

The results of the preliminary tests showed that adequately designed internals would be required in order to operate at flow rates significantly higher than the original design rate, with normal pressure drop and good flow distribution. The original vendor of the equipment was therefore asked to design and fabricate new internals for flow rates up to 25 gpm/sq ft. To obtain good flow distribution at low as well as high flow rates, the vendor suggested the use of two separate laterals in the underdrain system. The upper lateral was designed for 25 gpm/sq ft and was used during operation at this rate, and the lower lateral was designed and used for the low flow rates during backwash, regenerant addition, and rinse. The arrangement of the internals as modified for operation at high flow rates is shown in Fig. 3.

The original anion resin had lost much of its operating capacity and had a limited life expectancy. It was thought advisable, therefore, to replace the material before beginning the long-term tests. A different type of quaternary amine polystyrene * was chosen as the replacement because it had proved to be more stable and promised longer life for routine plant service.

Operating Procedure

After several trial runs, a standard operating procedure was adopted for the long-term performance tests. Prior to a test run, each unit was isolated and regenerated using the original piping and auxiliary facilities. Each unit was then rinsed to waste accord-

* Permutit S-1, Type I; a product of the Permutit Co., New York, N.Y.

ing to standard procedures until the effluent met required standards. The units were then placed in service and operated at the test flow rates of 490 gpm (25 gpm/sq ft), using the new piping. This rate was maintained constant throughout the test run. Periodically, comparative test runs were made at 6, 16, and 25 gpm/sq ft to obtain operating-capacity data.

To simplify test procedures, the amount of exchange material in each

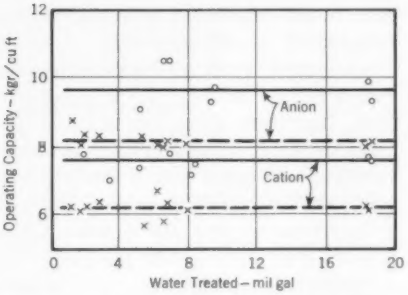

Fig. 4. Operating Capacity of Exchange Units During Long-Term Tests

Solid lines, 6 gpm/sq ft; dashed lines, 25 gpm/sq ft. Units were operated continuously until 19 mil gal had been treated. As shown above, operating capacities were 15 per cent lower for each unit at the higher flow rate.

unit was adjusted so that the units would exhaust at the same time. Thus, both units could be shut down simultaneously when one reached the established limit for exhaustion. It was unnecessary to operate the other unit to its specified limits for exhaustion, because the breakthrough near the end of the run had progressed sufficiently to make possible accurate estimation of the specified exhaustion point. During most of the test runs, the points of exhaustion on the two units coincided.

After several runs, it became apparent that the operating time for each run would remain constant at approximately 2¼ hr. For adequate control, therefore, checks of the effluent-water quality were made every 30 min. After 2 hr of operation, checks were made every 10–15 min. The close attention of the operators was required, owing to the rapid breakthrough at the high flow rate.

The field tests were designed to provide long-term operating experience. Accordingly, an operating period was chosen such that the total quantity of water produced was equivalent to that produced during 6 months of operation at the original design flow rate of 6 gpm/sq ft.

To meet this goal, the units were operated continuously until 19 mil gal of water had been treated. This quantity was equivalent to 0.4 mil gal/cu ft of each exchange material.

Results of Long-Term Tests

1. Water having a quality equivalent to that obtained at the original design rate of 6 gpm/sq ft was obtained throughout the long-term test period at 25 gpm/sq ft.

2. The operating capacity of both cation and anion units was 15–20 per cent lower at 25 gpm/sq ft than it was at 6 gpm/sq ft. This is shown graphically in Fig. 4.

3. At a given flow rate, the operating capacity remained constant within ± 10 per cent, the accuracy of the test procedures throughout the test period. This is also shown in Fig. 4.

4. The pressure drop through the cation and anion units at a given flow rate remained constant during each run and over the long-term test period.

5. No adverse chemical or physical effects on the exchange materials as

a result of the high flow rate operation were discerned from field inspections and laboratory examinations.

Conclusions

1. The long-term, field tests demonstrated that two-bed demineralizers will operate satisfactorily at flow rates as high as 25 gpm/sq ft.
2. Although the number of exchange materials tested was limited, it is believed that any of the modern high-capacity materials will perform satisfactorily at high flow rates.
3. The field tests demonstrated that adequately designed internals must be provided in order to minimize losses in operating capacity at higher flow rates.
4. Increased output from existing facilities as well as reduced investment for new facilities are the potential benefits of operation at higher flow rates.
5. The reduced operating capacity at higher flow rates results in lower operating efficiency.
6. Bed depth, flow distribution, and the reaction time of the exchange material are major factors which contribute to the reduction in operating capacity at higher flow rates.

Optimum Flow Rates

During the evaluation of the long-term test results, a review was made of the conditions that determine the optimum flow rate for a particular demineralization system. Some conclusions from this review may be of interest.

The potential advantages of operation at higher flow rates depend to a large degree on the minimum practical cycle time. This minimum cycle time determines the minimum quantity of exchange material required regardless of the design flow rate. Factors that affect the minimum practical cycle time include the exchange material's operating capacity, the solids content of the raw water, the required regeneration time for the exchange materials, the number of units in the system, and the amount of spare capacity necessary to insure continuous operation.

It can be seen that the benefits of operation at high flow rates vary inversely with the total solids content of the feed water. Thus, high flow rates have found practical application in the removal of small quantities of solids from waters such as condensate and demineralized water. To a lesser degree, high flow rates can also be applied to water softening and demineralization of waters with relatively low solids content. For example, although it would not be practical to operate the subject test units at 25 gpm/sq ft on a routine basis, the results indicate that the present operating rate of 6 gpm/sq ft can be increased to 10–12 gpm/sq ft. Thus, increased capacity is available from the existing equipment with a minimum of equipment alterations.

Economic Benefits

When higher flow rates are feasible, significant reductions in investment can be realized. This applies to increases in the capacity of existing facilities as well as to the design of new facilities. Using the subject test units as an example, investment for equipment and exchange material would be approximately 25 per cent less at a design flow rate of 12 gpm/sq ft than at 6 gpm/sq ft. The savings in investment would be slightly offset by increased operating costs, however, owing to reduced operating capacity at the higher flow rate.

Summary

The test results reported in this article and others show that high flow rates are practical for ion-exchange treatment of water supplies. These results do not, however, imply that higher flow rates are necessarily desirable. Limitations other than the ability of the material to perform satisfactorily may often determine the optimum flow rate. Each potential application must be evaluated by sound engineering judgment as well as economic comparisons to determine the optimum operating flow rate.

Acknowledgments

The author wishes to acknowledge the valuable assistance of C. S. Moore Jr. in the preparation of this paper, as well as the work of many other individuals who have taken part in this program. The cooperation of the Permutit Co. in designing and supplying the internals for the test units is also acknowledged.

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Centralized Remote Control

Kenneth L. Wilkerson

A paper presented on Oct. 30, 1958, at the California Section Meeting, Los Angeles, Calif., by Kenneth L. Wilkerson, Gen. Supt., San Gabriel Valley Water Co., El Monte, Calif.

THE field of telemetering and supervisory control is an extremely wide one, and one that is not unfamiliar to water utility people.

First, it should be understood that there are many types of electronic devices made and that all of them are engineering marvels. Therefore, it is not the author's purpose to give the technical details of the equipment involved, but rather to show what it can do.

All of California is growing in population, but certain areas have experienced truly outstanding growth. The San Gabriel Valley Water Co., with one operating division in the Fontana area and two in Central San Gabriel Valley, has met the challenge of an expansion from 1,146 customers in 1937 to 45,046 service connections of all types on Dec. 31, 1957. This 4,000-per cent growth may be surpassed by some utilities, but not by many.

This tremendous growth has brought about many operating problems. Increased demands have required the expansion of existing pumping plants and development of new pumping stations. The solution of one production problem created the next problem—that of procurement and training of personnel to maintain and operate the added facilities. The additional personnel required to meet peak summer demands, as compared to winter, sometimes resulted in a surplus of pump operators in the winter and, more frequently, not enough for summer maintenance and operations.

Development of Program

It was the El Monte division which the company selected for its first application of telemetering and remote control. The control of 25 turbines and 32 booster pumps was possible. All of the supply is obtained from wells ranging in depth from 140 to 700 ft. High-head turbine pumps, capable of pumping directly to the system, account for 20 per cent of the well pump capacity. The remaining twelve wells, located at six plants, deliver water to ground level reservoirs and tanks ranging in size from 92,000 to 600,000 gal. These twelve pumps have, in the past, all been automatically operated by means of tank level switches. Of the high-head booster pumps located at the six main plants, 29 can deliver 50 mgd from the tanks to the system. They have been operated automatically by sequenced pressure switches, meeting the demands of a virtually closed system. In addition, three boosters take water from the main system to an intermediate reservoir and to a high-level reservoir for one elevated district.

After consideration of a system of pumps spread over an area 10 mi east and west and 5 mi north and south, it was readily apparent that the greatest amount of pump control for the least amount of equipment and wire rental would be control for the 6 main plants. Control for the three remote boosters and the two reservoirs they feed was also most essential. Study of available telemetering equipment and desired functions began in 1954 and was concluded in December 1956, when an order was placed for telemetering and control equipment for three of the main plants, the associated boosters and reservoirs.

The objective was limited temporarily for several reasons. Even the small amount of equipment ordered involved an expenditure of approximately $30,000. There were only two installations of the selected brand, which could be observed in Southern California. The main reason for the decision to limit the order was to provide an opportunity to evaluate the equipment in action to determine whether or not any unnecessary or undesirable functions had been included or desirable ones excluded. Delivery of the equipment began in May 1957, and by December twenty pumps and five reservoirs were under central control.

In January 1958 a subsequent order was placed for the remaining three plants, and at the present time 44 pumps and eight reservoirs are under central remote control.

Nature of Equipment

The supervisory-control equipment, located at the company's main office near the center of the division, is contained in standing floor cabinets. For identification purposes each control panel has an assigned system number for the remote station or stations it controls and a telephone circuit number.

Tank or reservoir level, booster discharge pressure, and output to the system at each pumping station are continuously recorded in gallons per minute on 24-hr charts at the central station. A transmitter for each function at the remote station telemeters data in code form to the central office by means of tone equipment. Tone receivers continuously supply the information to the recorders.

The central control panel contains sets of pushbuttons and lights for each pump, marked "hand–off–automatic" for manual or automatic operation. At each of the remote plants there is local control for each motor by means of a switch associated with the pump starter. The normal position for these switches is the "automatic" setting. The pressure, tank level, or reservoir level switch for each pump starts the pump at a predetermined pressure or level so long as the control center switch is in the automatic position. If manual operation from the control center is desired, an override of the "automatic" position of the remote switches is provided, allowing the control operator either to place any pump in manual operation or to stop it and then reset it to the automatic position. In addition, memory status lamps, representing the above-mentioned switch positions, indicate the last command given for each pump. Also, two lamps are provided for each pump to show whether it is on or off.

Operation

Two types of supervisory and telemetering equipment are used in the

system; straight audio tone and pulse width selector. Both are of audio-frequency, but coded pulses enormously broaden the number of functions that can be transmitted on a single pair of wires. The pulse width selector will presently transmit 430 functions, as contrasted to 25 for straight audio tones, and is the principal distinction between the system selected and other available systems. Both systems are designed to operate over telephone lines. The tone signals are within the frequency range of 400–2,700 cycles per second, with a spacing of 100 cycles per second between tone channels for each function.

Audio tone systems employ a-c signals in the audible range. The audio tone transmitter consists of a tone-generating oscillator which is fixed, tuned, and sealed to generate a particular frequency.

Supervision and transmission of commands are achieved by the pressing of a command push button at the control center, which causes a relay to energize and key a tone generator. The tone generator oscillates at a stable, fixed audio-frequency. The signal is transmitted over the telephone line to a matching receiver. The received signal is then amplified, rectified, and results in the operation of a single-pole, double-throw relay. The relay actuates the remote "hand–off–automatic" operation.

The pulse width selector system is used between the central control station for one or more remote pumping stations, utilizing a single pair of voice quality telephone lines. Transmission of control command and supervision are performed by means of pulse coding of tones through the pulse width selector equipment over two tone channels, one in each direction of transmission. The pulse width selector could be considered analogous to a pin tumbler lock. Just as the key can only turn when the combination of pins corresponds to the notches in the key, the pump only can respond when the coded long and short signals correspond to the relay arrangement.

Special Features

If a change that is not initiated by a central control command takes place in the operational status of any of the pumps that change in status will cause the unrequested-change light at the central station to be illuminated and sound an alarm. A reset button is used to erase this indication.

In the event of a power failure at the remote station a signal light will be illuminated and alarm will sound. A switch is used to silence the alarm, but the light will remain on until power is restored. In addition to the indication at the control center a safety feature has been incorporated within the remote equipment. When the power fails all of the remote interposing relays are deenergized. They are not reenergized after the power has been restored until the control operator selects and operates from the central control station. This eliminates the possibility of simultaneous starting of several pumps. As a power failure at the pumping plant would also make it impossible to transmit any signals from the station to the central control panel, an emergency means is provided for energizing the tone unit that sends the power failure signal. This unit is powered by small, dry mercury batteries, quite similar to those used for sending radio signals from artificial satellites.

If a telephone line failure should occur, a line failure lamp at the central station would be illuminated and

an alarm would sound. A switch is used to silence the alarm. The line failure lamp remains lit until the telephone line is restored. Because a telephone line failure would affect all functions, the tank or reservoir level recording instrument is used for this indication and acts as the one check on the overall system.

Maintenance and Replacements

In addition to reliability and operational history, important considerations in the selection of any piece of equipment are its space requirements and simplicity of components and operation, maintenance costs, near and ready availability of manufacturers service personnel, spare parts required, price, and delivery. In the telemetering equipment selected by San Gabriel Valley Water Co. the tone generator units are of the plug-in type and are interchangeable throughout the central and remote panels. Two types of tone receiver units are used. These also are plug-in type. One spare generating unit and two spare receiving units are all that are required. The use of vacuum tubes is limited to five types. Six to eight of each type appears to be more than sufficient as spares. The manufacturer supplied an a-c–d-c test meter with four ranges together with plug-in earphones for checking tone signals for irregularity. Total investment in parts, including the test meter, was $278.00. A 12-month warranty was provided, covering all service and all parts except vacuum tubes.

TABLE 1

Annual Costs and Savings of Centralized Remote Control

Item	Amount $
Man-hours saved	+10,320
Truck mileage saved	+320
Telephone line rental	−2,359
Replacement parts	−116
Depreciation*	−2,649
Net saving	−5,516

* Installed equipment cost was $66,227.

No equipment is expected to be entirely trouble-free and with 18 months' experience the total parts expenditure for this equipment has been $172.80. It was originally estimated that vacuum tubes and miscellaneous parts for the entire system would be approximately $300.00 annually.

Net Savings Through Automation

Before the installation of telemetering and supervisory control equipment, nine men were needed to check reservoirs and pumping stations, handle radio calls, and dispatch emergency crews. They also dispatched and logged all routine field orders and maintained a 24-hr answering service at the main office. Today seven men perform these duties and check the control panel of the entire El Monte division. The operator can check all functions at a glance—water levels in all tanks and reservoirs, the output of each plant, and the discharge pressure and operating status of each pump.

In addition to the man-hours saved annually, the pump operators vehicle mileage has been reduced by 8 per cent, or 3,200 mi per year. Prior to the installation, the intermediate- and high-level reservoirs in the remote elevated district were checked every 2 hr daily. Only one trip a day is now necessary.

In order to determine what savings have been and will be made, a careful analysis was necessary. As the control equipment has gone into operation the number of pumps and the required supervision have continued to grow.

An analysis of equipment cost and annual savings is given in Table 1.

Conclusion

Automation and centralized control for San Gabriel Valley Water Co. has resulted in improved plant efficiency and economy of pump operation. The most economical combination of pumps is available instantaneously to meet changing demands of the system. From a combined-pump curve analysis the operator can reorganize the pumping program at any time. The previous system of sequenced pressure switches seldom arrived at the best combination even for a short period of the day.

Most important of all, service to our customers has improved. The operator now knows instantly when a pump fails, when there is any sudden heavy demand such as a major fire, a damaged fire hydrant, or a main break. At last the operator knows as soon as the customer does that some part of the system needs more pressure or attention.

Under no system of automation will machines every completely replace human beings, but automatic-control equipment may some day come close to eliminating equipment failures.

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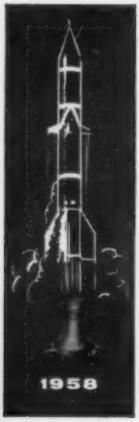

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When buying new water meters, a most important question of cost is: "In 30 years will this meter be *scrapped*, or will it be rebuilt to *1988* standards at a fraction of the cost . . . ready for years more accurate service?"

Take a look at the *past* 30 years. Think how much you're saving *this* year on Trident meters installed back in 1928 . . . or even 30 years before that.

Under Trident's strict policy of interchangeability, all improved parts are designed to fit old Tridents too. These up-to-date Trident parts embody every thoroughly tested advancement known to metering science. Not only is repairing easy and economical, but also you actually modernize your Tridents as you go.

This has been a rigid Neptune policy for 60 years. *Every design improvement now on our drawing boards will continue it.* It's your best assurance that the Tridents you buy today will stay modern, earning maximum revenue for your water system . . . at lowest cost . . . for many years to come.

2025

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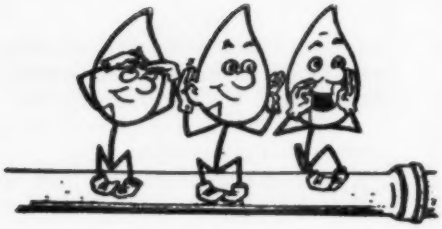


Percolation and Runoff

Stay away from 'Frisco,' we say, lest you be burned. No, we're not raking up the coals of the "Great Fire" again and, certainly, we're not suggesting that anyone shun everyone's favorite city—especially not next Jul. 12–17. It's the term we urge eschewal of, although just why we haven't yet been able to determine.

"Frisco" was where we invited everyone to come for AWWA's 79th Annual Conference—and indications are that almost everyone has accepted. But now, it seems, that we, ourself, may not be welcome for having used "that vile name" in referring to the "Queen of the Pacific." From Cucamonga to Fr-r-r—Fresno, that is—have come expressions of "astonishment" and "dismay," but not a one of explanation. "Frisco," it seems, is a dirty word, but no one knows why.

Reference books are no help either. Mencken, in *The American Language,* points out that the term is "frowned upon locally, but is used elsewhere," and notes:

> So far as I can find, no one has ever investigated the local abbreviations for town names. A few suggest themselves: *Jax* for *Jacksonville, Balto* for *Baltimore, Philly* for *Philadelphia, KC* for *Kansas City,* and *Chi* for *Chicago.*

Not to forget "Cincy" for Cincinnati, "LA" for Los Angeles, or, as the Marines tell it, "Dago" for San Diego. Elsewhere we were able to trace the name—still unexplained—back to the Placer *Times* of Jan. 14, 1854, wherein there was mention of "coming down to Frisco with a plough." But even in the suggestion that the name came from gold rush days there was no clue to why it was resented. Of course, the city might in those days have been a haven for pickpockets and, therefrom, earned a derogatory "Frisk-o." More likely, though, the name was a combination of the Swedish *frisk,* meaning fresh or healthful, and the French *eau,* meaning water. *Friskeau* is something that the city has had to import ever since it grew up, and what bald-head likes to be called "Curly"?

Whatever the count of anti-Frisco, who are we to rattle the skeleton in our hosts' closet, particularly feeling as we do that their metropolis is where we'd rather live than anywhere else in the world. Even the American Geographical Society of New York was recently moved to admit that this "undisputed capital of the West" is "blessed with a superlative setting, a mild climate, a harbor once described as 'capa-

(Continued on page 36 P&R)

(Continued from page 35 P&R)

ble of holding all the navies of Europe,' and a reputation for urbanity and charm." It is only to make certain that you make the very most of your stay there that we caution you now to stay away from "Frisco" and to remember that Van Ness is "Van'ess" Avenue. Even beyond this, as Mencken points out:

> It is a great point . . . to pronounce the name of Geary Street *Gary*, that of Kearny *Karny*, and that of Sutter with the *u* of *put*; doing so proves that one is an old-timer.

In short, for the biggest and best AWWA meeting ever, **COME TO San Francisco**

Secession, meanwhile, is the ugly word on the other coast, as New York City, in the throes of another bigger budget, sees "disengagement" from New York State and reconstitution into a 51st state as the only means of making ends meet. Without getting into the rather sizable legal and political problems that would be involved in such a schism, we rather suppose that the city's water supply, practically all of which is derived from upstate sources, might make it rather vulnerable to the untoward acts of a disinherited state. Of course, the costs of desalting lower Hudson River or even Atlantic Ocean water would probably turn out to be less than the "excess" of tax money now contributed by the city, and statehood would, obviously, leave Governor Wagner and an agreeable legislature to establish the city-state's own administrative and tax policies.

A little less imaginative in their approach, the editors of the New York *Times* have gone hunting for sources of additional income within the present organization. There, in addition to the suggestion of charging for "overnight and all-day parking" on the streets, they have come up with the thought of boosting city water rates, which have not been increased since 1934. Insofar as present rates "fail to cover rising costs, deferred maintenance charges, and added debt service costs of new water supply projects," a higher rate would, of course, be both legitimate and entirely desirable as a method of helping to balance the budget, although in New York, where a flat rate is generally regarded as no more than a "water tax," such an increase would represent little more than defining more accurately one portion of the property tax.

Giving the matter considerable thought now on Mar. 31, with a higher state income tax scheduled to take effect tomorrow, we lean more and more toward prompt secession. As a matter of fact, with a federal reckoning due on Apr. 15, we are ready to secede

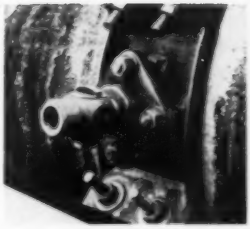
(Continued on page 38 P&R)

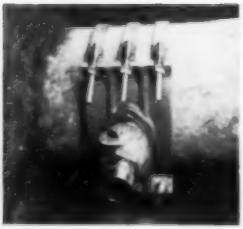
Tapping Water Lines Under Pressure

American Concrete Cylinder Pipe can be tapped with ease and economy while still under pressure.

The sudden explosive growth of many communities in the west has made it difficult for the best of advance planners to achieve both economy and adequate service in water supply systems designed for the future.

The possibility of unpredictable requirements for service outlets was one of the factors taken into consideration in the design of American Concrete Cylinder Pipe. Without de-watering the pipeline, small or large diameter outlets can be easily installed by any water works service group using standard tapping equipment. New outlying areas which mushroom in the typical western growth pattern can be readily integrated into a planned System if American Concrete Cylinder Pipe is used for the transmission lines.





CONCRETE PIPE FOR MAIN WATER SUPPLY LINES, STORM AND SANITARY SEWERS, SUBAQUEOUS LINES

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P.O. Box 12127 — Alpine 2-7566

(Continued from page 36 P&R)

even farther. Annexation by the United Nations area would, after all, leave us scot-free!

The meter reader goeth, it is said, the way of the iceman, and though pet pooches needn't start howling yet, we have to confess that a lot of effort is being expended toward disengagement of their hardbitten friends. Although the idea of remote reading of meters isn't new, the idea that it may be practical is, and the fact that two different proposals have been made in the past couple of months suggests that, relatively, it won't be long now.

First description of main-office meter reading came from Paul C. Constant at the Midwest Research Institute of Kansas City, who sent along a description of a technique for electronic reading over leased telephone lines. Then, through the New York *Times* we learned of a patent issued to a Curtis M. Cooper of Binghamton, N.Y., and W. Arthur Sprague of Ithaca, N.Y., for a system of punch card reading, computing, and billing, also based on the use of a telephone circuit. There are no doubt other systems, too, in development as well as in mind, and as they multiply the day of the meter reader no doubt divides.

Not only electronics but economics seems to have taken a hand in the meter reader's early end. At any rate, at Pipestone, Minn., Clerk Harold Lee has, after 9 months, pronounced his city's new policy of having customers read their own water meters "highly successful." Only 4 per cent of the city's 1,900 meters—those of a few elderly residents who have requested readings and those of the main industrial customers—are now being read by the utility and the result, according to authorities, has been saving in time, money, and public goodwill. As Lee indicated, the customers "do not feel a mistake has been made when they've read the meters themselves. We are no longer bothered with telephone calls to the city office about meter readers walking across the newly waxed or mopped floor or coming into the house without knocking. We feel avoiding these complaints is very important." "Out of line" readings are checked against previous records, but except under special circumstances meters are not reread until customers change.

It was just last month that the Associated Press reported, from Norfolk, Va., the opinion of veteran water meter reader Robert L. Daniel that the life is anything but a dull one, featuring his statement: "I've found everything from a bottle of whiskey to a possum in meters, as well as snakes and black widow spiders." These, of course, were in curb box meters; the findings of inside meter readers have often been even more interesting. Which is to suggest that when the meter reader goeth, much—including a close contact with customers—goeth with him.

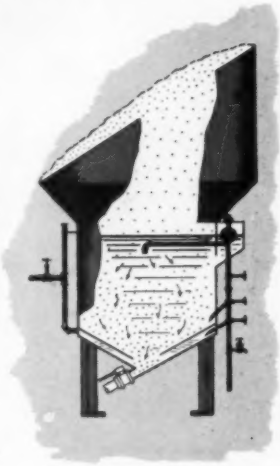
A 20-year bond guaranteeing the performance of its plastic pipe in cold-water service is being offered by Orangeburg Mfg. Co., Orangeburg, N.Y., to its customers. If the installation complies with the company's instructions, Orangeburg will, on request, issue a bond backed by a national surety firm to cover repairs or replacements due to failure of the pipe.

(Continued on page 40 P&R)

BRINE FILTRATION

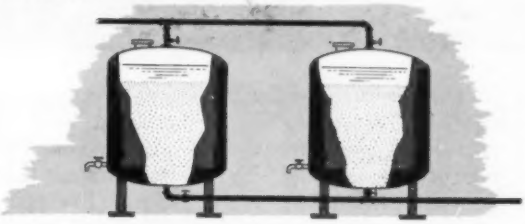
How it can affect design of water softening installations

Whichever filter medium you select—sand, gravel or anthracite, undissolved crystals of rock salt—this much is clear: dissolver design and regeneration expenses are bound to be affected. For example: Provision should be made for periodically removing the accumulated insolubles from the filter bed. Design of filters should incorporate the necessary cleanout facilities. And a brine-filtration setup that performs well with one type of salt may be inadequate with another.



The growing amounts of brine in use in today's large-capacity water softening installations complicate filtration problems. That's why treatment plant designers and builders are turning more frequently to International Salt Company. With over 50 years of experience and continuing research in all phases of salt handling and brine production, International can suggest many new and practical ideas in connection with salt purchase, storage and dissolving for regenerating ion exchangers. There is no charge for this service.

Service and research are the extras in STERLING SALT



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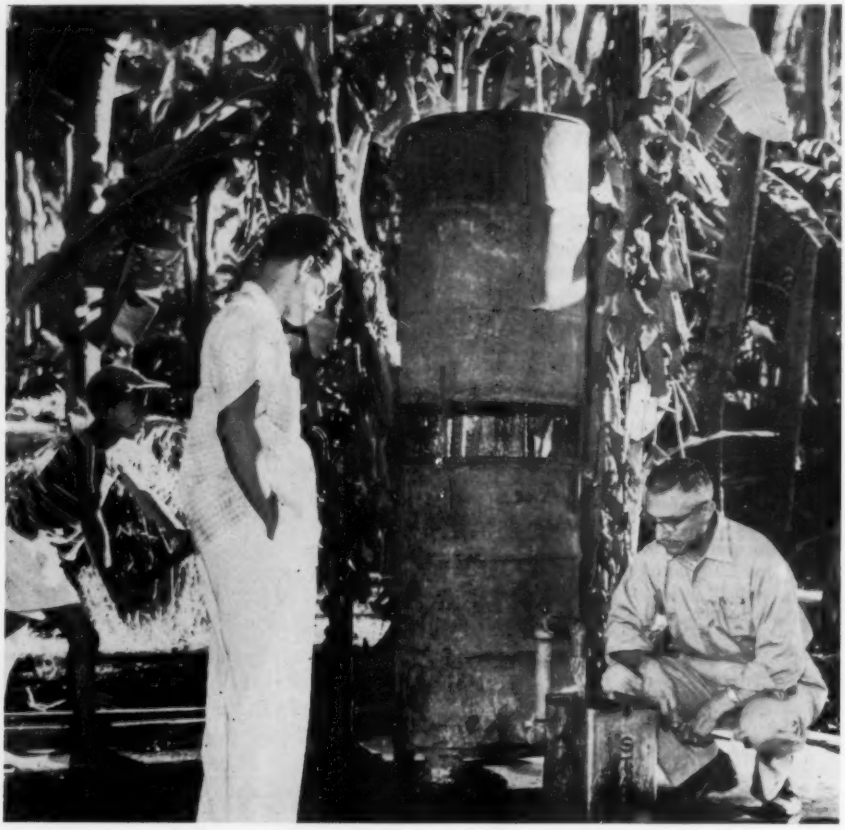
(Continued from page 38 P&R)

Drumming red water out of the Philippines is the job that Isadore J. Silverstone, water supply engineer with the International Cooperation Administration Mission in the Islands, appears to have accomplished with a new plant." The unit consists of a bamboo-slot aerator in an upper drum and a sand and gravel filter in a lower drum, made up at a cost of approximately $10. Coupled to hand well pumps, as shown in the illustration, such units



iron removal plant housed in two 55-gal oil drums (see cut). Adapting his design to take advantage of the abundance of empty drums available, Silverstone put together what is billed as "the world's smallest public water treatment are already removing iron hydroxide from at least 100 village wells previously considered unusable because their waters turned rice (main staple of the Philippine diet) purple, made coffee and tea coal black, and stained

(Continued on page 42 P&R)

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ELEVATED STEEL TANKS

When your elevated water storage needs are

large in scale

depend upon the unequalled experience of

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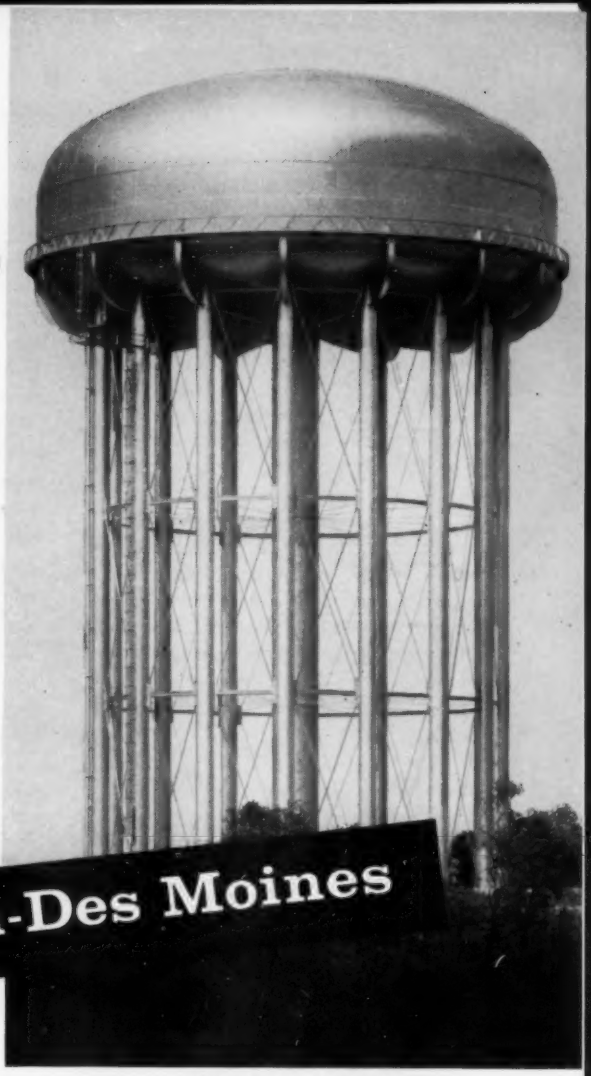

Pittsburgh, Pa. 2,500,000 Gallons

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Sioux City, Ia.
2,000,000 Gallons

Fort Wayne, Ind.
1,000,000 Gallons

Pueblo, Colo.
1,500,000 Gallons

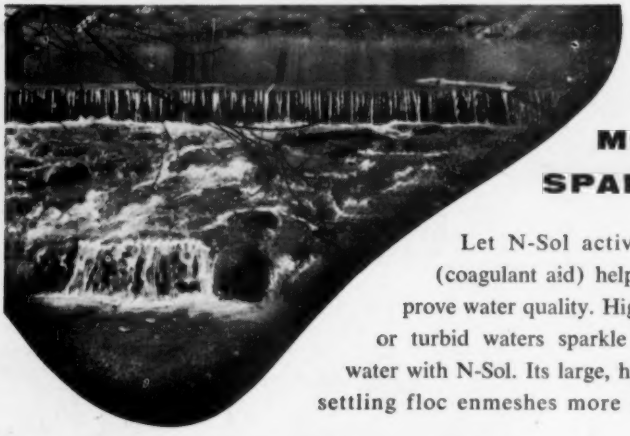
(Continued from page 40 P&R)

laundry a tattletale mud color. The National Waterworks and Sewerage Authority, with whom Silverstone is working as consultant, is busy supplying and installing new units as rapidly as it can put them together, thereby bringing into use for the first time many of the wells built with US assistance and scorned by the villagers because of the red water they produced. To make wells sound, it seems, old drums can't be beat.

An old gold mine, meanwhile, was the material at hand adapted to another engineering design—in Alaska, of course—on a $1,500,000 water supply improvement project for the city of Juneau. There, prospectors Archie Rice and Ken Bielman of the consulting firm of Cornell, Howland, Hayes & Merryfield struck it rich in discovering an abandoned mine tunnel which can be used as an aqueduct to carry the new supply all but a few hundred feet of the distance from the new well field, half a mile from town, to the distribution system. There will be speculation, of course, on whether the mine may have been abandoned too soon. Even if it wasn't, the water department is several thousand pipeline dollars richer; but if it was, Juneau will have a pay cock in every sink.

Nelson M. Fuller has been named executive engineer of the Monroe County (N.Y.) Water Authority. He was formerly superintendent of the water and sewer department at Batavia, N.Y.

(Continued on page 44 P&R)



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Write for copy . . . **"Jar Test Procedure for Activated Sili Sol".**

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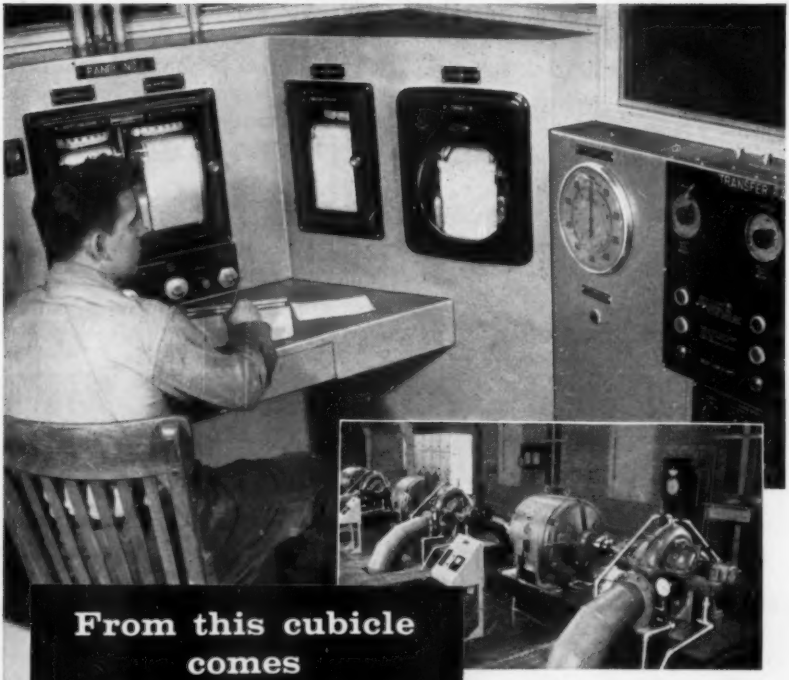


From this cubicle comes advance proof of pump performance

Typical A-C pumping installation is this one in the District No. 2 Water Works at Pueblo, Colorado. Motors and control are also supplied by Allis-Chalmers.

This master control room of Allis-Chalmers pump test floor is far removed from public works installations. Yet engineers working here know exactly what your needs are — and which Allis-Chalmers pump will best do the job.

Performance testing like this is only one reason why A-C is recognized as a full-line leader in meeting the pump needs of municipals. "Teamed" motors and control; customized standardization of parts and materials; engineering assistance and nationwide service are others.

Whatever your requirements in centrifugal pumps — from the smallest to 250,000-gpm giants — contact your A-C representative or distributor. *Or write to Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.*

ALLIS-CHALMERS A-5981-PW

(Continued from page 42 P&R)

'General carelessness and a spirit of nonchalant incompetence' are characteristic of more graduates today than ever before, in the opinion of ASCE President Francis S. Friel. He goes on to point out, in a speech at Manhattan College's School of Engineering, that this is true even though "facilities of education have progressively improved and both the quality of instruction and the caliber of aspirants to the profession have risen." Many graduates seem to expect that industry and the professions will be satisfied with the 70 per cent performance which represents a passing grade in the classroom. Particularly striking, Friel says, are deficiencies in writing and speaking.

While our own experience in procuring capable editorial staffers has brought us into contact with more than a few "nonchalant incompetents," we are certain that not all recent graduates merit such condemnation. Among the

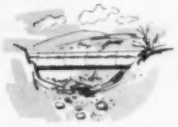
Celebrating Hersey Mfg. Co.'s 100th anniversary at the Massachusetts Water Works Assn. meeting in Dedham, Mass., Board Chairman Walter A. Hersey fondly pats a disc meter which, despite 38 years of service and encasement in a cypress tree root, is still in good operating condition. Looking on are, left to right: Francis P. Hersey, vice-president of the meter firm; Gordon A. Dillon, MWWA president; and John S. O'Reilly, Hersey's New England sales manager.

(Continued on page 46 P&R)

STEEL PIPE IS RELIABLE AND RESILIENT

is your water supply safe from...

WASHOUT



SOIL MOVEMENT

SURFACE VIBRATION

WATER HAMMER

"wherever water flows...steel pipes it best!"

STEEL PLATE FABRICATORS ASSOCIATION

105 WEST MADISON STREET * CHICAGO 2, ILLINOIS

(Continued from page 44 P&R)

outstanding non-nonchalants are the recipients of Harry E. Jordan Scholarships, as witness the following progress reports from them:

After receiving my master's degree from Massachusetts Institute of Technology in June 1958, I accepted employment with Esso Research & Engineering Co. in Linden, N.J. I have been working in the Construction Engineering Div. with a section that is responsible for the proper construction of oil refineries and chemical plants. I am presently assigned to the home office and am engaged in general administrative work. I plan to acquire experience in the construction and operation of refineries by field assignments, and then to transfer to consulting work in air and water pollution caused by refineries.

HERBERT H. HASSIS
Jordan Scholar '57

I completed my studies and received my M.S. degree in sanitary engineering in January 1958. At that time I became an instructor in civil engineering at Rutgers, where I began part-time studies toward a Ph.D. in the fall of 1958. Although I enjoy college teaching very much, I feel I must try another type of work before deciding what course I should follow in pursuing my career. I am therefore suspending my doctorate studies and have accepted a position with the Pipe Div. of Johns-Manville Corp. to begin in June.

WILBERT H. SCHLIMMEYER
Jordan Scholar '57

I am presently employed as an associate engineer by the Port of Oakland, Calif. In this position I am responsible for the planning and design of various engineering projects, ranging from structures and airport development to water pollution control, water supply, and sewerage installations. While this position is not exclusively concerned with sanitary engineering, I have found it very rewarding in the technical and professional experience I have gained. I have taken the state examination for registration as a professional engineer.

MARVIN R. LINDORF
Jordan Scholar '56

I plan to work for the Div. of Water Pollution Control, Texas Dept. of Health, as a sanitary engineer. This job involves making studies of sewage and industrial-waste treatment plants to determine adequacy of facilities and effects on quality of water in receiving streams.

JAMES D. GOFF
Jordan Scholar '58

After a year of graduate study at the University of Wisconsin, I was awarded an M.S. degree in civil engineering in August 1956. My major field of study was sanitary engineering. During the school year I was elected to the honor society of Phi Kappa Phi. I joined Stanley Engineering Co., Muscatine, Iowa, after leaving Wisconsin. My first year was spent working with the design and report groups on sanitary and hydraulic projects. In December 1957 I was placed in charge of the firm's Sanitary Engineering Design Section, which I still head.

PAUL A. KUHN
Jordan Scholar '55

Pigeons in the gas, alas, was the response of the nation's birdlovers to the campaign of St. Louis Health Commissioner J. Earl Smith to rid his city of its pouting population. Actually, it seems that only one of the protesters had any objection at all to plying the birds with alcohol-saturated grain; it was the coup de gas that they universally condemned. In persisting in his plans to put the pickled pigeon project in practice, Dr. Smith has the support of the water department, whose reservoirs are also allergic to squab slobs; he undoubtedly derives additional comfort from the fact that his victims will at least die *happy*.

(Continued on page 48 P&R)

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Get chlorine products any way you want them, in any amount you need, from just *one* dependable source—Jones Chemicals.

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Get chlorine in any amount—from 16-lb. cylinders to 1-ton tanks. Jones packages high-purity chlorine in less than carload lots—then lets you pick the size and type of container you need.

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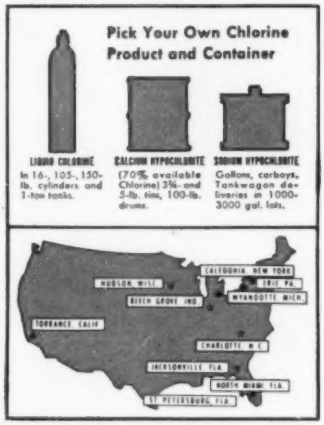

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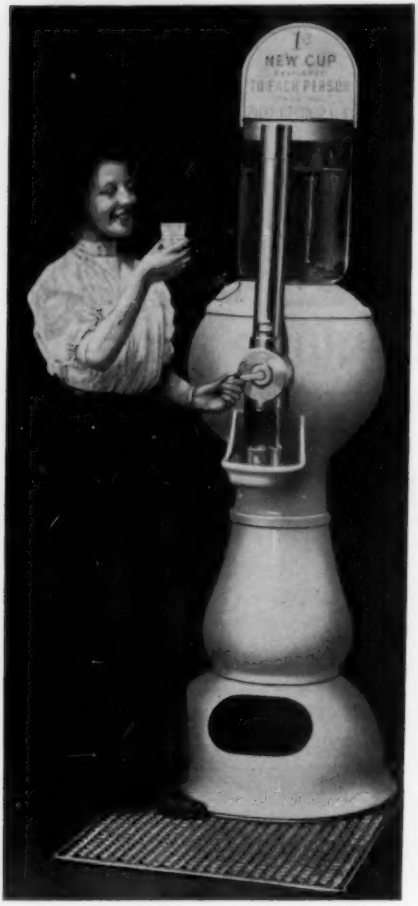
(Continued from page 46 P&R)

Water safety—the drinking variety, that is—dates back at least 2,600 years to Cyrus the Great, who insisted that his water be boiled before he drank it. But publicly speaking, 1908 was the year when safety was consciously added to the service provided by a water utility. That was the year of Boonton and Bubbly Creek—the year that chlorination became a practical method of disinfecting a public water supply. But 1908 brought yet another measure of water safety that we have too long overlooked in our celebration of chlorination—1908 brought the Dixie Cup to preserve the safety that chlorine engendered. And if the paper cup was at first no more intentionally safe than Cyrus's slaking, it was certainly more quickly and more profitably made intentional—and by water suppliers, too! The story, as it was related in the 1958 Annual Report of American Can Co.:



[In the spring of 1908] a company was formed in New England to sell one of the world's most plentiful products—water. A penny bought a drink of pure, cold water. The paper cup in which it was vended was incidental.

Yet, in less than 2 months, it was realized that the true potential of the infant enterprise lay in the paper cup—not the water. That was the beginning of the paper cup industry, which today is doing a $250,000,000-a-year business. It also was the beginning of one of the world's most famous trade names—"Dixie Cup."

In 1908 the common drinking cup was a menace to health in trains, stations, schools, and other public places. The founders of the young drinking water company foresaw that the paper cup not only could perform a public service by abolishing the common cup, but also could start a new industry.

The railroads were among the first to install penny vendors to dispense individual paper drinking cups on trains and in stations. The early railroad business gave the young company an assured market and the revenue to begin expansion into other business areas as state after state banned public drinking vessels as menaces to health.

The original paper cup, very simply constructed by present-day standards, was trademarked "Health Kup" in 1912. Soon growing demand for the "Kups" spurred the redesigning of production machinery

(Continued on page 50 P&R)

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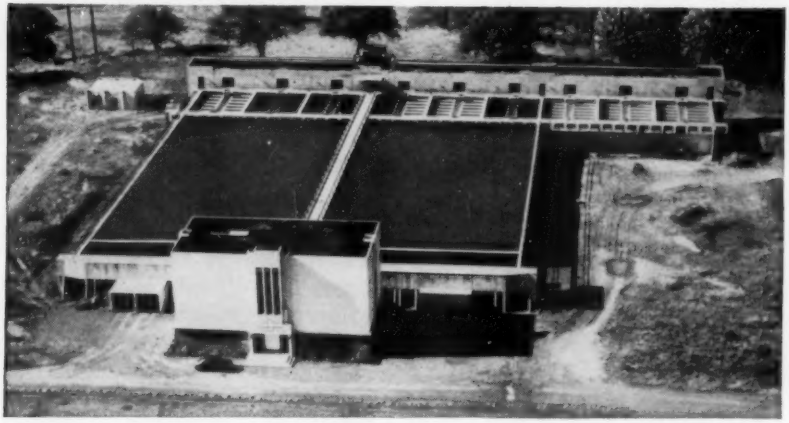

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(Continued from page 48 P&R)

to produce a more rigid cup. Shortly another machinery improvement gave even greater rigidity with the innovation of a rolled brim. The "Health Kup" now began to find new markets, especially in soda fountains, and in 1919 the trademark was changed to "Dixie Cup."

World War I, with its violent flu epidemics, gave new life to the growing paper cup industry. Shortly after the war, Dixie Cup began producing cups for home use. . . .

The rest you know, though you may not realize that Dixie Cups are now made in approximately 800 types and styles and are sold by the billions throughout the world. Meanwhile, though it, too, has found a good many new markets and popularity, water remains pretty much the same in type and style—a little softer here perhaps, a little better for the teeth there, less corrosive in spots, and not so stainful, perhaps, but essentially the same, safe, necessary, profitless product.

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(Continued on page 52 P&R)

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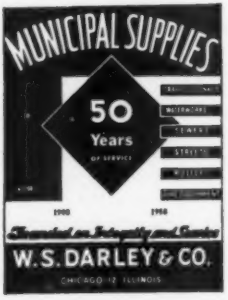

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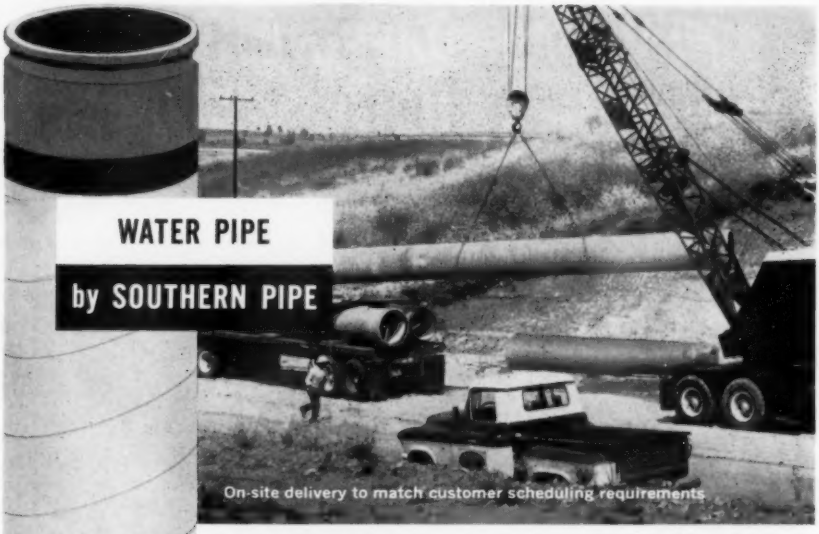

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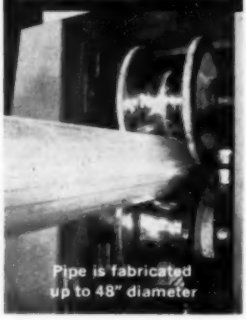

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(Continued from page 50 P&R)

Everett M. 'Casey' Jones has been named assistant to the vice-president of the Meter & Valve Div., Rockwell Mfg. Co., Pittsburgh. He was formerly vice-president and general manager of Simplex Valve & Meter Co., Lancaster, Pa.

The advisory committee on revision of the USPHS Drinking Water Standards held its first meeting Mar. 24–25 in Washington, D.C. In view of changes in the nature and extent of impurities in water supplies resulting from population growth and technological and industrial development, the USPHS felt it desirable to appoint this advisory committee to reevaluate the standards, which were first formulated 45 years ago and last revised in 1946.

Although the Drinking Water Standards were originally written to apply only to water used on interstate carriers, state health departments have accepted them as standards for public water supplies. This general acceptance makes it mandatory that they be kept current and that the basic knowledge required to deal with new problems of impurities be developed before they become acute. At the first meeting special attention was given to the problems involved in setting limits for nonliving contaminants such as radionuclides and synthetic organic pollutants and other chemicals.

The official representative of AWWA on the committee is Oscar Gullans, chief water chemical engineer at Chicago. Many other AWWA members are on the committee as representatives of numerous scientific and technical associations and federal agencies. The roster includes: T. E. Larson, D. A. Okun, F. W. Gilcreas, H. J. Ongerth, Paul Kabler, M. B. Ettinger, S. K. Love, T. R. Camp, L. M. Beacham Jr., L. G. Lederer, R. A. Downs, W. D. Stovall, R. S. Glynn, F. R. Hassler, E. C. Jensen, J. B. Hursh, C. C. Croft, H. G. Magnuson, H. E. Stokinger, J. G. Terrill, M. C. Hope, and F. S. Kent. O. C. Hopkins and R. L. Woodward are co-chairmen, with G. W. Burke Jr. secretary.

(Continued on page 106 P&R)

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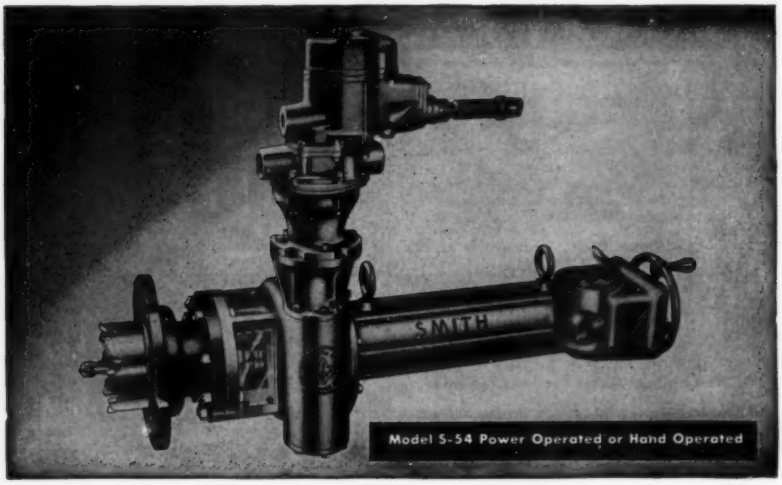

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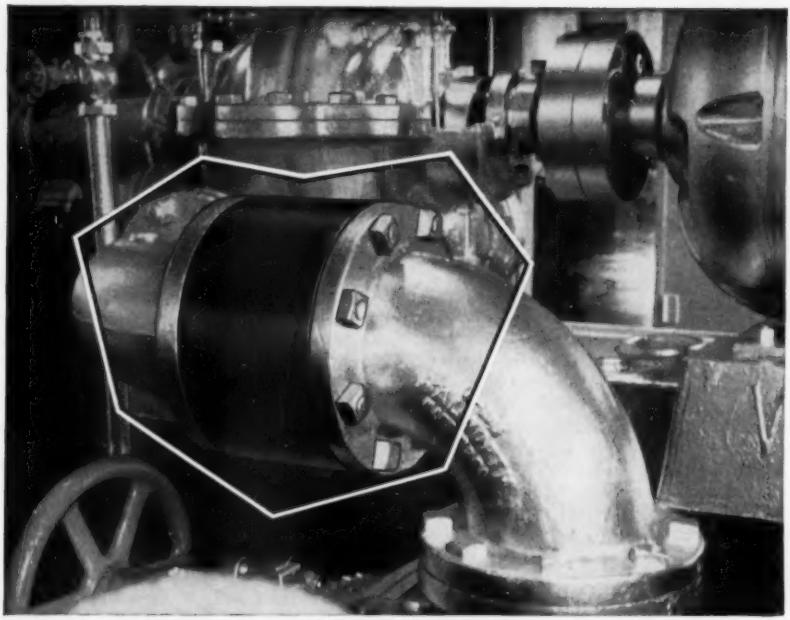

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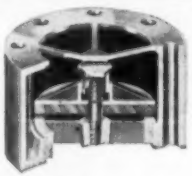

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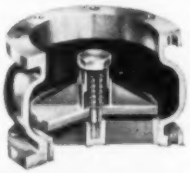

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

BACTERIOLOGY

The Effect of Oxygen Supply on the Rate of Growth of *Aerobacter cloacae*. R. Elsworth; V. Williams; & R. H. Smith. J. Appl. Chem. (London), **7**:269 ('57). Effects of limited oxygen supply on growth rate of *Aer. cloacae* in batch culture has been studied. Eqs. have been evolved for calcg. rate of soln. of oxygen in 20-l culture vessel, oxygen demand of growing culture, and growth rate of bacteria when oxygen supply is greater than, equal to, or less than oxygen demand. Concn. of bacteria in 20-l culture vessel was measured at intervals and, by use of eqs. const. growth rate and concn. of bacteria under limiting conditions of oxygen supply were detd. Details of exptl. procedure and medium used are given, and results are shown in tables and graphs. It was concluded that with normal oxidation rates at atmospheric pressure in 20-l vessel bact. growth rate would be restricted.—*WPA*

Ammonification of Organic Nitrogenous Substances in Water and Bottom of Sevan Lake (USSR). M. E. Gambaryan. Doklady Akad. Nauk Armyan. S.S.R. (USSR), **23**:183 ('56). Sevan L. in Armenia carries highest pop. of ammonifying bacteria in spring of yr. In bottom sediments highest pop. is found in silts, in lowest in sandy structures. Bacteria which mineralize org. N compds. are most numerous in latter half of yr. Thus, mineralization of proteins continues yr. around.—*CA*

Coliform Bacteria in the Testing of Water and Their Differentiation. R. Schubert. Z. Hyg. Infectionskrankh. (Berlin), **142**:476 ('56). Various types of coliform bacteria, fecal and nonfecal, and methods for their differentiation described in the literature are discussed. Tables are given of types isolated by author from human and animal feces and other material and from water. Development is then described of mannitol-indol nutrient medium in which tests for gas production from mannitol and indole formation can be made at 44°C. Tests with 250 strains showed no difference between indole reaction at 44°C in this medium and in carbohydrate-free medium at 37°C and no difference in gas production from mannitol and from lactose at 44°C. Simplified method, using 3 tubes, for identification of fecal coliforms and partial identification of other types, is described.—*WPA*

Sanitary Significance of Different Varieties of Coliform Bacteria Isolated From Water. M. G. Kichenko. Zhur. Mikrobiol., Epidemiol., Immunobiol. (Moscow), **28**:62 ('57). Bact. flora of healthy persons and persons with diarrhea was investigated. It was found that diarrhea cases had lower proportion of coliform group. Effect of diet was also investigated. Biochem. properties of fecal bacteria change in water. Author feels that all coliform bacteria can serve as indicators of fecal contamn. of water and there is no point in complete identification of organisms.—*PHEA*

Coliform Group. I. Boric Acid Lactose Broth Reaction of Coliform IMViC Types. H. F. Clark et al. Appl. Microbiol. **5**:396 ('57). Coliform strains were collected from 14 geographical areas of US and were divided into 12 different types by their IMViC reactions. 4,423 strains were so tested and in boric acid lactose broth which was incubated at 43°C for 48 hr. There were 731 strains of + + − − type of which 682 (93.3%) gave positive results in boric acid lactose broth medium. No. of strains included in 11 other types amtd. to 3,692, and 500 (13.5%) of those produced positive cultures with boric acid medium. These results are not sufficiently specific either way to recommend boric acid broth for rapid identification of *Esch. coli* giving + + − −

(*Continued on page 64 P&R*)

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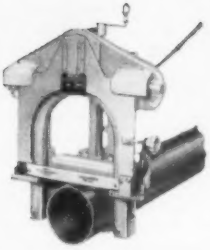

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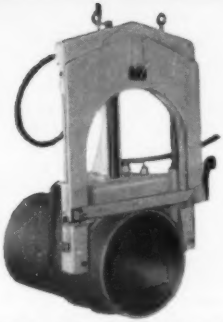

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(*Continued from page 62 P&R*)

IMViC reactions. There was wide variation of results between different localities. By use of indole test together with boric acid test no. of false reactions was reduced.—*BH*

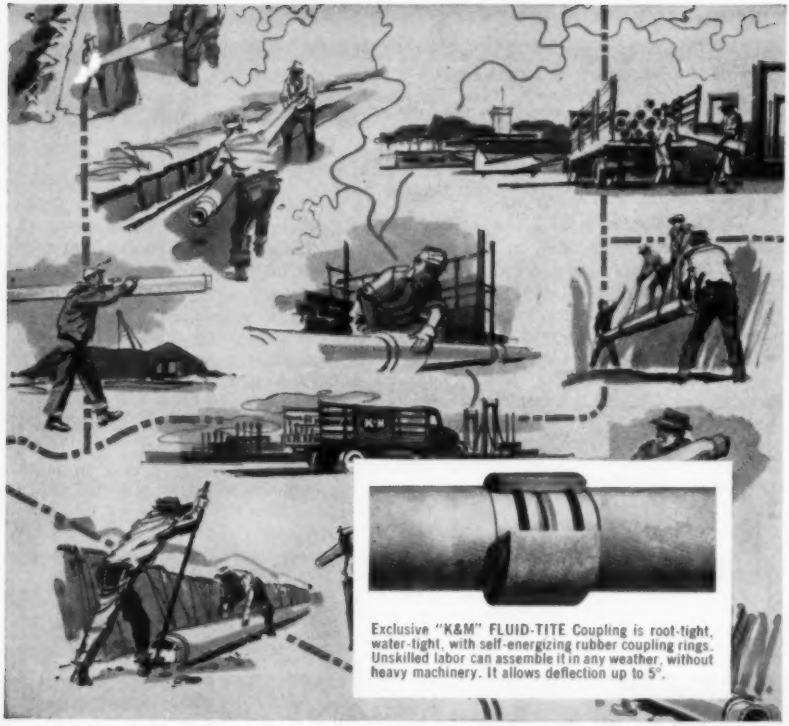
Removal of Coxsackie and Bacterial Viruses in Water of Known Chemical Content by Flocculation With Aluminium Sulfate or Ferric Chloride Under Various Testing Conditions. S. L. CHANG ET AL. Am. J. Pub. Health, **48**:51 ('58). Adequacy of modern water treatment processes in safeguarding public from waterborne virus diseases was challenged by '55–'56 outbreak of infectious hepatitis in New Delhi (India). Quant. information regarding destruction of pathogenic viruses in water by chlorine is scant and that regarding their removal by flocculation is almost nonexistent. 2 questions arise which require further investigation: (1) Is information obtained with bact. virus applicable to removal of pathogenic viruses, and (2) Is information obtained with water prepd. in lab. applicable to treatment of natural raw waters. Series of studies reported here deals with way in which certain pathogenic viruses differ from bact. viruses in their behavior in flocculation process of water treatment. Eff. of aluminium sulfate and ferric chloride in removing Coxsackie and bacterial (*Staphylococcus albus* phage) viruses were ascertained and some of the conclusions derived were: (1) At 25°C and pH 6.2, 40 ppm aluminium sulfate removed 86.3% of Coxsackie virus and 93.5% of the bact. virus. Under similar testing conditions similar doses of ferric chloride removed >98% of both these viruses. (2) In presence of bicarbonate buffer optimum pH for removal of both viruses by aluminium sulfate flocculation was in 6.2–7.2 range, but even at pH 8.2, fairly good floc formation was observed and 80% removal of bact. virus was obtained. (3) When settled floc produced with aluminium sulfate was resuspended and agitated 60% of Coxsackie virus and 10–25% of bact. virus were sepd. from floc. Attempts to separate these viruses from floc formed with ferric chloride were unsuccessful.—*BH*

Detection of Dysentery Bacteria in Artificially Infected Water by the Phage Titre Increase Reaction. D. M. GOLDFARB. Zhur. Mikrobiol., Epidemiol., Immunobiol. (Moscow), **28**:24 ('57). By application of phage titre increase reaction to experimentally infected water low concn. of dysentery bacilli (0.32 organisms/ml) could be detected. Positive result depends on type of water, length of time elapsing after infection, and bact. concn. in water. In experimentally infected well water bacteria could be detected by means of phage titre increase reaction in lower concn. and over longer period of time than in tap or river water.—*PHEA*

Determination of *Escherichia coli* 1 in Sea Water. J. K. JOHANNESON & R. E. MARTIN. J. Appl. Bact. (London), **20**:151 ('57). Lactose broth frequently gave higher presumptive and confirmed counts for detn. of *Esch. coli* 1 from sea water compared with results with MacConkey broth. In presumptive count 53 samples gave higher counts with lactose broth than with MacConkey broth, 11 had equal counts, and 25 had smaller counts. After confirmation corresponding no. of samples were 39, 10, and 27. Advantage of lactose broth was in samples giving MPN of <100 *Esch. coli* per 100 ml. At higher MPN values both media were satisfactory, but MacConkey broth might give higher yield of *Esch. coli* owing to suppression of high concns. of non-coli-aerogenes bacteria. It appears that lactose broth without inhibitory ingredients could be used, with advantage in examn. of sea water. —*BH*

Biological Processes in the Estuarine Environment. VIII. Iron Bacteria as Gradient Organisms. L. G. M. BAAS-BECKING; E. J. FERGUSON; & I. R. KAPLAN. Koninkl. Ned. Akad. Wetenschap., Proc. Ser. B (Amsterdam), **59**:398 ('56). Iron bacteria (comprising genera *Sphaerotilus* and *Gallionella*) are "gradient organisms" and develop only under conditions where marked increase in Eh occurs. pH-Eh limits lie within pH 4.6–8 and Eh 200–500 v. **IX. Observations on Total Base.** Ibid., 408. Besides carbonic acid–bicarbonate system other buffering systems were found in estuarine waters, most important being the $SH^- \rightleftharpoons H_2O$ system. At high, const. salinity tot. base (**I**) may be considerably lowered. Apart from diln., changes in **I** in estuarine environment are probably caused by biol. processes.—*CA*

(*Continued on page 66 P&R*)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(Continued from page 64 P&R)

Is BOD a Measure of the Load or of the Activity of the Bacteria? G. VAN BENEDEN. Centre belge etude et document. eaux, Bul. mens. (Belg.), **No. 68–69**: 313 ('56). Conclusions derived from series of tests are that primary factors affecting BOD are no. and activity of bacteria and amt. of N available. —*CA*

Viability of Sewage Bacteria in Sea Water. G. T. ORLOB. Sewage and Ind. Wastes, **28**:1147 ('56). Present state of knowledge on viability of bacteria in sea water is summarized and critically analyzed. There is considerable disagreement over extent and causes of bact. diminution. Die-away is characterized by typical curve which includes lag phase, logarithmic decrease phase, resistant phase, and sometimes aftergrowth. Predominant bactericidal agent is biol. in nature and is diminished by heating, filtration, or chlorination of sea water. Sedimentation and adsorption also are signif. factors in removing bacteria while addn. of nutrients to sea water may offset bacterial effect by stimulating growth. Increasing temp. generally increases die-away rate and reduces lag period, but sunlight, bacteriophage and salinity are considered less important. Addnl. research needed is outlined.—*PHEA*

On the Microflora of the Water Surfaces. S. M. DRATCHEV; L. E. KORSH; & O. V. MITAYAGINA. J. Hyg., Epidemiol., Microbiol., Immunol. (Prague), **1**:431 ('57). Surface films of water were investigated by touching liq. with sterile slides or sterile loops and examining them bacteriologically. Layer of water examd. in this way is about 1 mm thick and contains 2–10 times more saprophytic bacteria than body of water below surface. Org. matter in surface layer was studied by analyzing foam found on surface of water. There was an increased concn., especially of nitrogenous and other sol. substances. Saprophytic bacteria and *Esch. coli* in foam outnumbered cont. of these microorganisms in body of water by 100–1,000 times.—*BH*

(Continued on page 68 P&R)

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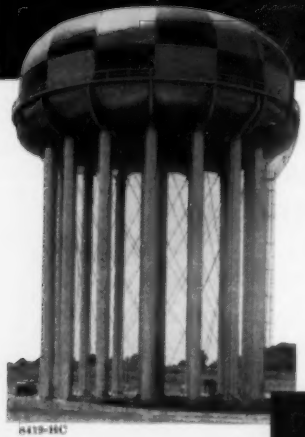

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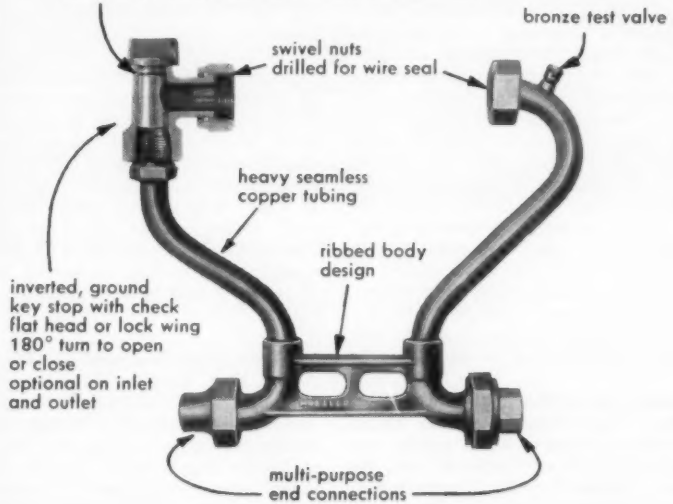

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(Continued from page 66 P&R)

Detection of Typhoid Bacilli in Water Using the Increase of Phage Titre Reaction. D. M. Gol'dfart & Z. S. Ostrovskaia. Zhur. Mikrobiol., Epidemiol., Immunobiol. (Moscow), **28**:636 ('57). By means of increase of phage titre reaction presence of organism of typhoid fever can be demonstrated in artificially infected water in concn. of 75–750 bacilli per ml by continuing expt. for 10–11 hr. In expts. lasting 22 hr typhoid bacilli can be demonstrated in tap water in concns. of 0.1, 0.01, and 0.02, and in river and well water of 10 and 100 organisms per ml. Sensitivity of increase of phage titre reaction is considerably greater than that of bact. examn. and depends on character of strain and presence of other microorganisms in water. 1 of fundamental conditions for detection of typhoid bacilli in water by means of prepared indicator phage is presence of Vi-antigen in them. Expts. carried out show that Vi-antigen may be preserved for long time in bacteria found in water. After prolonged existence in water typhoid bacilli undergo marked changes in their basic properties, most evident in biochem. activity. Agglutinability, however, which includes Vi-serum, and phage-sensitivity are preserved at this stage, changing only after much longer period of time.—*PHEA*

Investigations on Typhoid Vi-Phage From the Water of the Danube in the Galati (Rum.) Area—Relationship Between the Presence of the Bacteriophage and the Incidence of Morbidity in Riverside Villages. C. Zilisteanu & C. Combiescu. Microbiol., Parazitol., Epidemiol. (Bucharest), **2**:17 ('57). Samples of water collected from Danube R. in '52–'54 in Galati area, Rum., have been examd. for presence of typhoid Vi-phage by 1–3 prelim. enrichments in presence of Vi strain of *Salmonella typhi*, followed by plating on same strain as indicator organism, and also on other organisms of enteric group in order to establish specificity. Vi-phage was found in most samples, particularly in neighborhood of towns in which epidemics of typhoid fever had occurred. It was not found in samples of water from 8 wells in same area.—*BH*

Presence of Vi-Phages in Waters in the Hanoi (N. Vietnam) Region. H. Leclerc. Ann. inst. Pasteur (Paris), **92**:369 ('57). Author examd. 430 samples of river water and 30 samples of lake and stagnant pool water in Hanoi (N. Vietnam) for presence of Vi-phages. He used as indicators 3 strains of *S. typhi* which had been isolated locally, 2 Ballerup strains, and *S. typhi* Watson. Phages active against Vi strains of *S. typhi* were isolated from 180 (41.8%) of specimens. They could be subdivided into 4 groups according to plaque size and specificity of action. Those giving largest plaques (>2 mm diam.) lysed only Vi strains of *S. typhi*. Next group (1.3–2.0 mm diam.) contained some Vi-specific phages and also some *Salmonella* O phages. Intermediate group (0.7–1.3 mm) and smallest group (<0.7 mm) consisted mainly of polyvalent phages which attacked wide range of salmonellas, shigellas, and other Enterobacteriaceae. Proportion of phages in each group which were specific for *S. typhi* Vi strains ranged from 100% of largest plaque group to 38% of smallest plaque group. *S. typhi* Watson was most valuable indicator strain because of its greater sensitivity and specificity while Ballerup was considered to be least useful—all phages revealed by it were of small polyvalent variety. —*BH*

Canicola Fever in Japan. T. Misao et al. Am. J. Hyg., **63**:294 ('56). Survey of sporadic cases of infection with *Leptospira canicola* in the area of Fukuoka (Jap.) and epidemic of cases in villages of Raisan, Ito, and Hojo is presented. Results of tests for isolation and serological detection of etiological agent are presented. Discussion of clinical symptoms of disease is given. Disease was presumed to have been waterborne and source of causative agent was evidently infected dogs. Anal. of incidence of *Leptospira canicola* in dogs from above areas is presented.—*PHEA*

Action of Free Available Chlorine on Bacteria and Bacterial Viruses. L. Friberg & E. Hammarstrom. Acta Pathol. Microbiol. Scand. (Copenhagen), **38**:2:127 ('56). Effect of free available chlorine in water disinfection was studied on bacteria (*Bact. coli, Salm. typhi, Salm. typhi-murium, Sh. sonnei, Staph. aureus, Str. pyogenes* and *Str. faecalis*) and on bact. viruses (*Bact. coli* phage T 2, *Salm. typhi* phage E 1, *Salm. typhi-murium* phage 34 and *Sh. sonnei* phage IV). Period of exposure to chlorine was 1 min.

(Continued on page 72 P&R)

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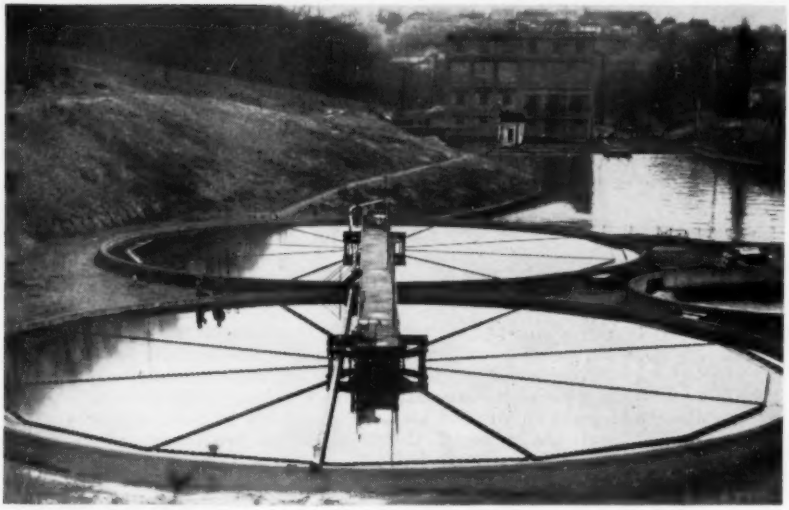

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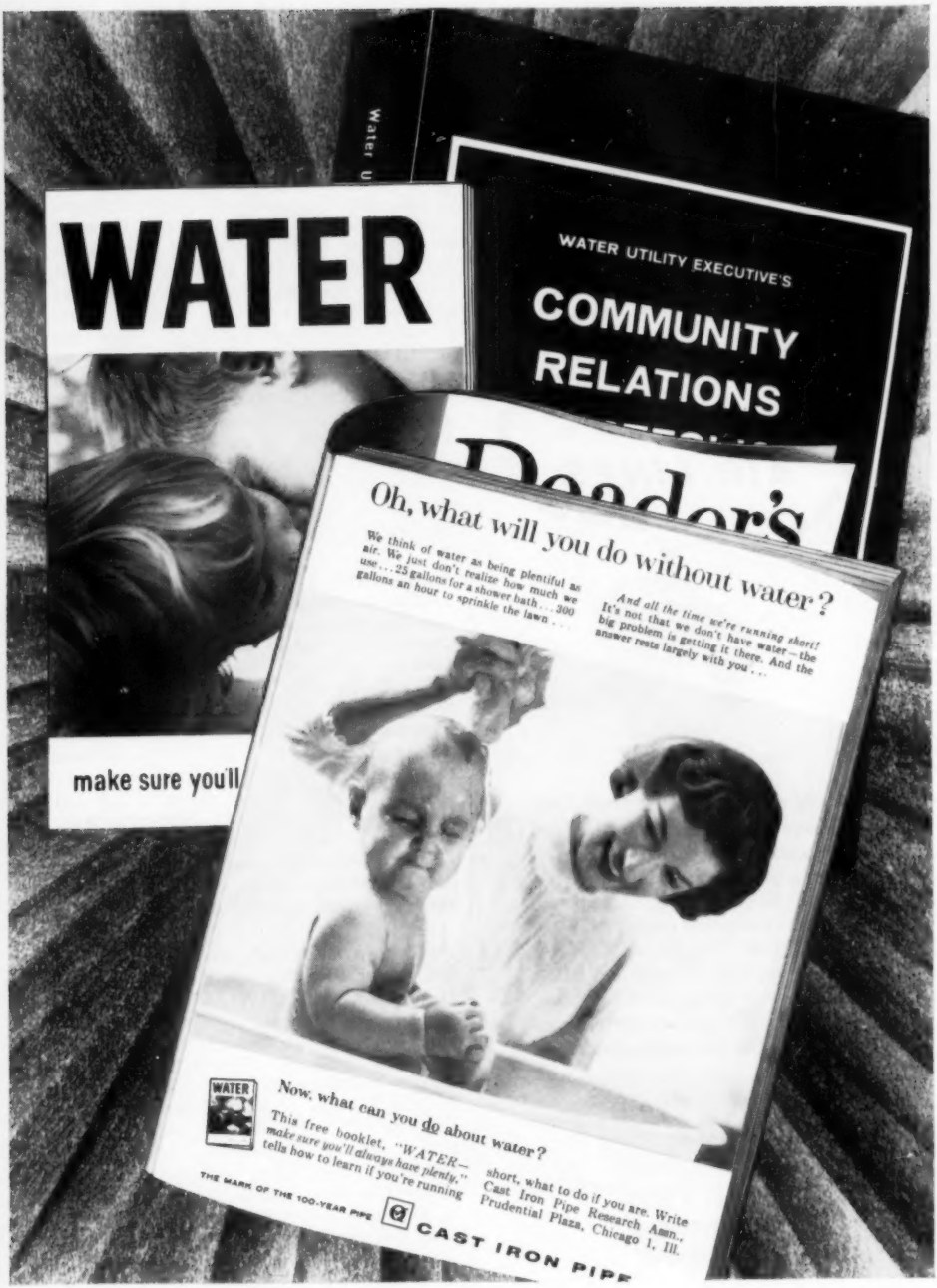
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AIR LINES

(*Continued from page 68 P&R*)

At 6°C and pH 7.2 typhoid, dysentery, and coli bacteria required dose of 0.025–0.05 mg/l of free chlorine to bring about 1,000-fold reduction. *Salm. typhi-murium, Str. faecalis* and *Staph. aureus* were somewhat more resistant, corresponding dose necessary being 0.10–0.15 mg/l. 1,000-fold reduction of coli, dysentery, and typhi-murium phages was obtained with dose of 0.04–0.07 mg/l free chlorine at 6°C and pH 7.2, that is to say, amt. of same order of magnitude as that needed for most highly sensitive of bacteria examd. In cases of *Str. pyogenes* and typhoid phage reduction curve was not strictly linear. 2 parts of curve could be distinguished, namely, 1 rising steeply to about 100-fold reduction (0.10–20 mg/l) and another, more level part at 1,000-fold reduction and dose of 1.0 mg/l. From typhoid phage 2 chlorine-resistant variants were isolated. Bactericidal as well as virucidal action of free available chlorine increased with falling pH and rising temp.—*BH*

An Epidemic of Canicola Fever in Man With the Demonstration of *Leptospira canicola* Infection in Dogs, Swine, and Cattle. I. Clinical and Epidemiological Studies. H. R. WILLIAMS ET AL. Am. J. Hyg., **64**:46 ('56). Epidemic of canicola fever, involving 26 persons, is discussed. Swimming hole contamd. by domestic animals was source of infection. *Leptospira canicola* infection was demonstrated in dogs, swine, and cattle in area, all of which had access to water supplying swimming hole. Presence in patient of grippe-like anicteric illness, coupled with history of swimming in possibly contamd. water, should suggest diagnosis of leptospirosis.—*PHEA*

Evaluating Bacterial Contamination in Sea Water Samples. G. T. ORLOB. Public Health Reports (US), **71**:1246 ('56). Changes in pop. of coliform bacteria in contamd. sea water during early hr immediately following collection of sample may have signif. bearing on interpretation of results of bact. surveys. Refrigeration of samples, although generally recommended when extended storage of samples is necessary, is not always capable of minimizing bactericidal effect of sea water. Direct inoculation of sample into cold media at sampling site, with 5–6 hr delay in incubation, produces

(*Continued on page 74 P&R*)

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(*Continued from page 72 P&R*)

results which are generally comparable with direct inoculation into tempered media followed by immediate incubation. This method is used by Poln. Control Commn., Wash., and is recommended for general use on bact. surveys of sea water.—*PHEA*

The Importance of Technical Method in the Examination of Drinking Waters for *Bact. coli*. J. F. BRAUNE. Arch. Hyg. u. Bakteriol. (Munich), **140**:1/2:28 ('56). In Ger. recommended method of water examn. is still a nutrient gelatin plate count and presumptive coliform count on Endo medium, inoculated direct or after enrichment in glucose peptone soln. This procedure is criticized in relation to practice of other countries. Author suggests further examn. of coliform colonies by IMViC tests. In present study 2-day plate counts at 22 and 37°C were combined with filtration of 200 ml of water through a Coli 5 membrane filter. ½ of membrane was placed on Endo plate and remainder placed in glucose broth with 3% ox-bile. Both media were incubated at 45°C for 24 hr. Colonies from Endo plate and from subcultures of glucose broth were examd. for motility, gelatin liquefaction, indole production, growth in citrate, and by MR and VP tests. Of 254 individual colonies investigated by these methods, 225 were MR-positive, VP-negative, and citrate-negative. This fig. included indole-positive and indole-negative strains. Only 7 strains were definitely placed in *Aerogenes* group. In parallel study of coliform colonies from 100 specimens of feces, 92 out of 100 strains were MR-positive, VP-negative, and citrate-negative. Author briefly recapitulates general evidence that only fecal coli is of sanitary signif. in bact. examn. of water supplies.—*BH*

Storage of Water Samples for Bacteriologic Examinations. J. A. MCCARTHY. Am. J. Public Health, **47**:971 ('57). Author presents results of 1-yr study of samples collected from surface sources of water supply. Coliform counts were made by multiple-tube method within ½ hr of collection

(*Continued on page 76 P&R*)

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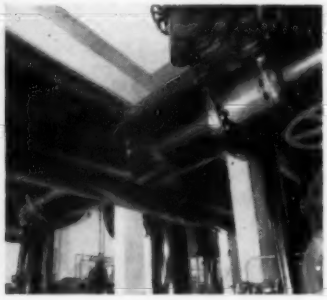

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(Continued from page 74 P&R)

of sample and again after storage of portions of sample for 24 hr at room temp. and in refrigerator. Results indicate that samples with relatively low coliform densities which have been in transit for max. of 24 hr at any reasonable temp. will give coliform counts not significantly different from those that would have been obtained if samples had been examd. very soon after collection. Samples with coliform densities of order of 230 and more may be more likely to exhibit decrease in coliform cont. after 24-hr storage.—*BH*

An Outbreak of Infectious Hepatitis in Two Arctic Villages. R. A. DAVIS. New Eng. J. Med., **256**:881 ('57). Characteristics of outbreak of infectious hepatitis in Arctic are described. Relations between geographic distr. of cases, human contamn. of sources of water supply and explosive nature of epidemic are propounded as reason for conclusion that this particular outbreak was result of fecal-oral mode of transmission with water acting as vehicle.—*PHEA*

Infectious Hepatitis. Report of an Outbreak Probably Caused by Drinking Water. J. W. MOSLEY & W. W. SMITHER. New Eng. J. Med., **257**:590 ('57). 18 cases of infectious hepatitis in Daviess County, Ky., were investigated. Epidemiologic evidence concerning transmission is presented. It is felt that at least 9 of cases were due to ingestion of water from private wells contamd. from 1st known case. Survey of sanitation was carried out and indicated contamn. of these wells. It is believed that waterborne hepatitis may be more frequent than is reported, particularly in rural areas where water supplies are often poorly protected.—*PHEA*

Bacterial Identification by Infrared Spectrophotometry. II. Effect of Instrumental and Environmental Variables. B. A. KENNER ET AL. J. Bacteriol., **75**:16 ('58). Comparable spectra of bacteria by infrared spectrophotometry can be made when standardized conditions are maintd., such as identical culture media, incubation times and temps., conditions of harvest, and similar procedures in prepn. of films on AgCl discs. Const. instrumentation controls must also be maintd. This paper discusses and illustrates the effect of variable conditions on infrared spectra of bacteria.—*PHEA*

The Problem of the Influence of Polyethylene Synthetic Pipes on the Bacteriological Quality of the Water. R. H. LAUN. Gas- u. Wasserfach. (Munich), **99**: 121 ('58). Synthetic pipes are especially advantageous for constr. of home connector terminals where mains must be laid in aggressive soil types. Opinion concerning their usefulness from bact. point of view is confusing. This report was prepared by Bavarian office for water supply. Comparative studies clarified behavior of bacteria comparing polyethylene pipes, bituminous cast-iron pipe, and galvanized pipe in standing water. In local main with home connections of polyethylene pipe, water conditions in polyethylene pipes in mottled sandstone and shell limestone was examd. and compared. Test conditions were described. Elastic high-pressure polyethylene pipe appears to behave indifferently to pathogenic and nonpathogenic bacteria.—*PHEA*

The Effect of Thiosulphate and of Phosphate on the Bactericidal Action of Copper and Zinc in Samples of Water. R. C. HOATHER. J. Appl. Bacteriol. (London), **20**:180 ('57). As result of increasing use of copper and galvanized pipes samples of water for bact. examn. frequently contain traces of copper or zinc. These metals exert fairly rapid bactericidal action in sampling bottle. Expts. have shown that bactericidal action of copper can be prevented by thiosulphate usually put in sampling bottles to neutralize chlorine; 100 mg/l is satisfactory amt. for general use. Bactericidal action of zinc can be prevented by addn. of small amt. of sodium phosphate to ppt. zinc. It is stressed that, when special sampling points are installed, copper or galvanized pipes should be avoided.—*WPA*

RADIOACTIVITY

Uptake of Fission Products and Neutron-Induced Radionuclides by the Clam. J. K. GONG; W. H. SHIPMAN; & S. H. COHN. Proc. Soc. Exptl. Biol. Med., **95**:451 ('57). Study of uptake of 3 neutron-induced radionuclides (Zn^{65}, Fe^{59}, and Co^{60}) and 2-mo.-old mixture of fission products by clam demonstrated ability of this animal rapidly to concn. signif. quants. of these radionuclides in both shell and soft tissue. Uptake of radioactive material in soft tissue is metabolic incorp.; higher uptake by shell appears

(Continued on page 78 P&R)

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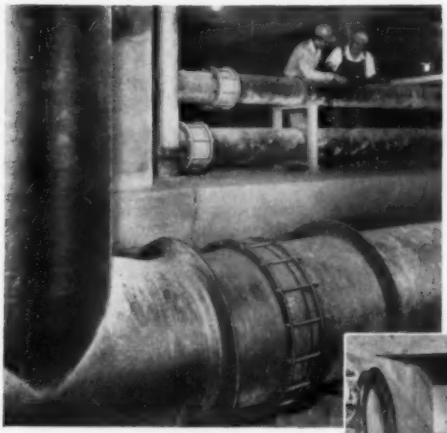

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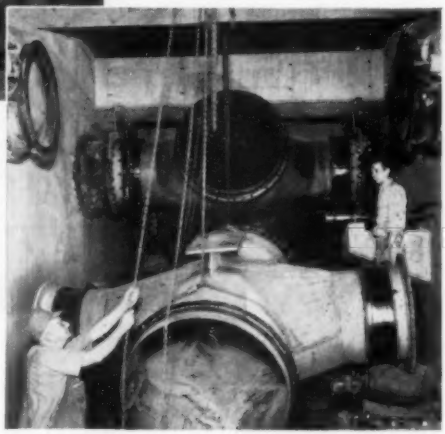

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(Continued from page 76 P&R)

to be surface adsorption phenomenon. Rate of incorp. by soft tissues was const. and was highest for rare earth group of fission products. Uptake of Co^{60}, Zn^{65}, and Fe^{59} was also const. but occurred at much lower rate. Sr^{89} and $Ru^{103-106}$ were taken up only in equil. with radioactive medium in exptl. interval studied. Further study with radionuclide Co^{60} indicated that rate of uptake varied as power function with level of concn. of radionuclide in medium. Ability of clam to conc. radio-elements to high deg makes it valuable as biol. indicator of radioactivity. It may be particularly useful in assessing contamn. of marine areas with low levels of radioactivity.—*PHEA*

Radioactive Contamination of Fish in Waters Containing Strontium. M. M. SAUROV. Trudy Vsesoyuz. Konf. Med. Radiol., Voprosy Gigieny i Dozimetrii (USSR), 66 ('57). Observations were made of 4 species of fish in 120-l aquaria at 4 different concns. of Sr^{90} in equil. with Y^{90}. Expts. were conducted for 5 mos. Several hundred specimens of fish were tested and examd. for Sr cont. in scales, bones, muscle tissue, and internal organs. It was found that after prolonged periods of time intense accumulation of Sr^{90} takes place. Detailed quant. data are given. In general, direct relation was established between deg of Sr^{90} concn. in tissues, activity of water, and time. Accumulation was found to be inversely proportional to concn. of Ca in water. Scale and bones concns. about 40 times as much Sr as muscle tissues and internal organs. Max. accumulation is reached in 1–2 mo in various parts of body. Permissible limits of radioactive Sr^{90} for open-water reservoirs was established, subject to corrections to account for Sr^{90} accumulation by various organisms.—*CA*

Biological Deactivation of Water Containing Radioactive Substances by Means of Special Ponds. E. A. TIMOFEEVA-RESOVSKAYA. Byull. Moskov. Obshchestva Ispytatelei Prirody, Otdel. Biol. (Moscow), **62**: 1:37 ('57). Sand and soil show adsorption of radioactive materials; water organisms,

(Continued on page 80 P&R)

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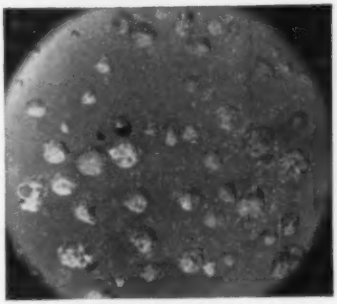

Photomicrograph of Nalco 614 particles shows one of the reasons for its excellent handling and dry feeding characteristics: spherical grains that assure free flow through conventional dry feeders.

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There is no substitute for full-scale use of a new product to prove its usefulness and advantages. Here are some of the results that water works report after putting Nalco 614 to work:

"Saved almost $1,000 per Month over the cost of previous treatment, principally alum," says one filtration plant superintendent.

Replaced Alum and Ferric Sulfate at a municipal water plant in Iowa. This plant softens water to 85 ppm. Previous cost of alum, iron, lime and soda ash was $239.00 per day. Replaced 25 parts alum and 50 parts ferric sulfate with only 8 parts Nalco 614. Lime and soda ash dosages also reduced because of 614 alkalinity. Cut overall chemical cost to $150.00 per day; a saving of $89.00 per day — $32,485.00 per year!

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Here are some typical comments on Nalco 614 handling characteristics:

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(*Continued from page 78 P&R*)

such as plankton and periphyton, show absorption. It was, therefore, tried to deactivate Sr^{90}, Y^{90}, Zr^{95}, Nb^{95}, Ru^{103}, Cs^{137}, and Ce^{144} in dosages of 10–25 $\mu c/l$ by letting such solns. run 1st thru sand-soil filter and then thru pond with such organisms, or to do the same by using pond 1st, then filter. As much as 99% of radioactive material was retained this way and eff. was especially high, if much detritus and slime from organisms were present in water.—*CA*

Removal of Radioactive Contaminants From Water by Ion-Exchange Slurry. W. J. LACY & D. C. LINDSTEN. Ind. Eng. Chem., **49**:1725 ('57). Radioactive contaminants from bomb fallout or improper disposal from reactor installations can be reduced by batch treatment with mixed-bed ion-exchange resins such as Amberlite MB-3, Amberlite XE-69, Zeo-Dur, and Permutit Q. Lab. contaminant mixes made up to approx. 4,000 counts/ml were reduced by batch-type treatment and column-type operation. Deg of removal is detd. by: tot. dissolved salt cont. of water; ionic or colloidal state of contaminant; type of ion-exchange material; chem. valence of contaminant; pH value of waters (feed soln.). —*CA*

Water for Nuclear Engineering. S. K. LOVE & W. F. WHITE. Ind. Eng. Chem., **48**:1248 ('56). Dissolved and suspended matter in surface water and ground water must be considered when these are used for nuclear-energy development. Surface waters vary in qual. throughout yr as result of many natural and man-made influences. Ground waters are ordinarily less subject to change in qual. than surface waters. In many streams concn. of dissolved solids at low flow will exceed by several times concn. during periods of high flow. Reverse generally applies to concn. of suspended solids. When water contg. fission products is mixed with clay, radioactive elements are transferred from soln. to surfaces of sediment particles. Adsorption and ion exchange are somewhat more effective in ground water than in surface water. Some soils remove certain radioactive isotopes by adsorption, ion exchange, or biol. concn. Range of concn. is illustrated of naturally radioactive substances normally found in surface and

(*Continued on page 84 P&R*)

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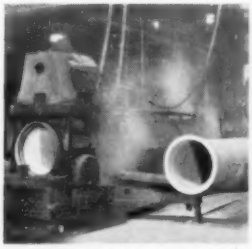

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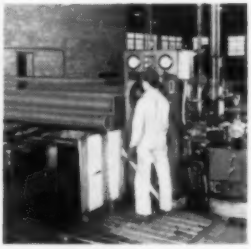

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(*Continued from page 80 P&R*)

ground waters. Man-made factors make it difficult to det. with certainty what part of observed radioactivity of water is natural. Ground water samples must be treated immediately on collection to stabilize Ra and U in soln. Other complications arise in detn. and interpretation of relative proportions of dissolved and suspended solids.—*CA*

Nuclear Long-Range Fallout in Surface Waters. C. G. Bell Jr. J. San. Eng. Soc., ASCE, Proc., **83**:1400 ('57). Based in part on samples from NBS rather extensive calibration measurements indicated a fallout beta (disintegrated)/(count rate) ratio of 2.8 $\mu\mu$c/cpm for water samples and ratio of 2.5 for rain samples. Avg. of most radioactive set of surface water samples collected in eastern Mass. following Nov. '52 Eniwetok detonations registered 6.9 cpm/l or 0.02 $\mu\mu$c/ml. As peak radioactivity concn. in rain and surface waters occurred about 1 mo after these tests, AEC—Civil Defense Admin. beta concn. level for 30-day water consumption appears pertinent. This indicates that for drinking water purposes, Ivy test would have had to dischg. (31,000 $\mu\mu$c/ml/(0.02 $\mu\mu$c/ml) = 1,500,000 times as much fission radioactivity to reach above-mentioned level in eastern Mass.—*PHEA*

The Public Health Implications of Radioactive Fallout in Water Supplies. H. A. Thomas Jr. Am. J. Public Health, **46**:1266 ('56). Signif. increases in radioactivity in Mass. streams occurred only when pptn. took place through radioactive air masses. During period from Nov. '51 to Jun. '53 there were 24 detonations. Only 5 were followed by fallout extensive enough to raise radioactivity above natural levels. Max. observed in any sample was about 3×10^{-7} μc/ml of tot. beta activity 3 days after fission. This represents 0.006% (3×10^{-7}/5×10^{-3}) of AEC upper limit for potable water std. Findings are that small addnl. exposure from nuclear weapons testing programs in US is not health hazard or seriously affect genetic constitution.—*PHEA*

Content of Radioactive Elements of the Thorium Series in Mineral Springs of Japan. VIII. Mineral Springs in Chugoku and Shigoku Provinces. K. Shimokata. Nippon Kagaku Zasshi (Tokyo), **77**:848 ('56). Among 70 spring waters analyzed for Th series elements (**I**) by thoron method, 25 waters were found to contain 0.5–26 $\times 10^{-5}$ g Th units/l. Conts. of MsTh and RdTh were calcd. No relation was found between conts. of **I** and of Rn. Spring water contg. large amt. of residue on evapn. was high in **I**. Sediments contained 0.08–6.21 $\times 10^{-3}$ g Th units/g. **IX. Mineral Springs in Kyushu.** Ibid., 854. Among 66 spring waters only 4 waters were found to contain 0.6–4.8 $\times 10^{-5}$ g Th units/l.—*CA*

Calculation of MPC of Radioactivity in Air and Water. H. Cember & M. A. Shapiro. J. San. Eng. Div., Proc. ASCE, **83**: 1174 ('57). Fact that radiation damage is proportional to absorbed energy provides means for calcg. MPC values for many radioactive environmental contaminants. These calcd. MPC values are based on max. exposure rate of 300 millirem/wk, corresponding to absorption of 30 ergs/g of tissue for beta or gamma radiation. If biol. behavior of any particular radioisotope is known, then MPC may be calcd. that would result in exposure at this rate.—*PHEA*

Determination of the Radioactivity of Ground and Surface Waters. E. Wosalho. Gas- u. Wasserfach. (Munich), **99**: 322 ('58). Radioactivity of natural waters, due largely to K^{40}, cannot be detd. by instruments now available. However, where amt. of alk. earth compds., etc., is low, est. can be made from residue after evapn. Where dry residue is relatively large masking effect may be too great to give accurate results for natural radioactivity. In such cases it is desirable to separate K and Sr and det. β-activity of these fractions. Dry residue is evapd. to dryness with concd. HCl 3 times after treatment, and then dissolved in HCl. Alk. earths are pptd. as sulfates. Sulfate-contg. filtrate is then used for sepn. of K as K-Al sulfate. Mg is then detd., and β activity of both K and Mg fractions is detd. Similarly, alk. earths are fractionated to give Sr fraction, activity of which is detd. Spectroscopic methods can be used to det. whether compn. of ground water has changed over period of time, for example, to det. whether increase in β activity was due to ground water or dust from an atmospheric explosion. These methods are relatively rapid to carry out and can be used to follow changes in ground water and detect radioactive contamn.—*CA*

(*Continued on page 86 P&R*)

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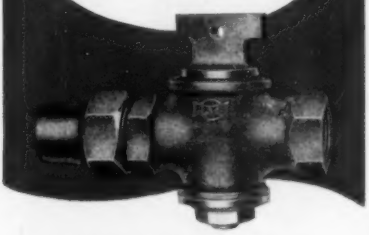
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(Continued from page 84 P&R)

Radioactivity Measurements of Mineral Waters in Rumania. IV. Radioactivity of Potable Water in Cluj. A. SZABO. Acad. rep. populare Romine, Filiala Cluj, Studii cercetari chim. (Bucharest), **7**:1–4:111 ('56). Potable water in surroundings of Cluj contains on avg. 1.15×10^{-12} g Ra/l, but its product of disintegration, Rn, is present in larger amts. because of its greater soly. Ra is found deep in ground as insol. salts (silicates and sulfates). Radioactivity of these waters corresponds to 1.14 megacycles for both Ra and Rn.—*CA*

System Continuously Records Water Level and Contamination. F. KALIL & J. M. GARNER JR. Nucleonics, **14**:56 ('56). Design of elaborate electronic device is given which will continuously record water level and gamma activity of large body of water and is not affected by debris, algae, or weather conditions. It uses anthracene crystal which is kept suspended at constant distance above water surface by means of servo-mechanism. Water level is detd. by float in a stilling well. Information from both detectors is amplified and recorded in nearby instrument shack, from which information is transmitted over telemetering system to distant office. Radiation-monitor, calibrated with combination of 7 gamma emitters, has efficiency of 0.2. This instrument may prove useful in monitoring streams or lakes into which is dischgd. waste from large nuclear energy installations, but its cost and electronic maint. problems probably preclude its wide application to civil defense problems.—*PHEA*

Measurements of the Radioactivity of the Rumanian Mineral Waters. VII. The Radioactivity of the Waters and Muds of the Sovata and Praid Salt Lakes and Mineral Sources (Rum.). A. SZABO & A. SOOS. Acad. rep. populare Romine, Filiala Cluj, Studii cercetari chim. (Bucharest), **8**:1–2:135 ('57). Only L. Negru in Sovata region has measurable activity (Rn 0.96 mache [1 mache $= 3.6 \times 10^{-10}$ curies] and metallic Ra 9.65×10^{-12} g/l). Origin of this radioactivity is explained by muds of mineral origin and org. deposits at bottom of lake. Sulfurous thermal water of artesian well of Praid is also radioactive (Rn 3.2 mache and Ra 31.5 $\times 10^{-12}$ g/l). This radioactivity is below limits necessary for medical therapy and has to be increased artificially.—*CA*

(Continued on page 88 P&R)

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(Continued from page 86 P&R)

The Radon and Radium Concentration in the Springs and Mineral Deposits of the Waters of the Borsec and of the Toplita. VIII. A. Szabo. Acad. rep. populare Romine, Bul. stiint., Sect. stiinte mat. si fis. (Bucharest), **9**:537 ('57). Exptl. methods for detn. of Rn and Ra were described previously. Only 1 spring, Pierre Curie of Borsec, is strongly radioactive (7.24 mμc of Rn and 8.20×10^{-12} g of metallic Ra). This radioactivity comes from mica schist layers. For past 30 yr radioactivity of these springs has not varied significantly.—*CA*

The Radon, Radium, and Uranium Concentration of the Mineral Waters and Calcareous Tuffs at Singeorz-Bai (Region of Cluj, Rum.). A. Szabo & A. Soos. Acad. rep. populare Romine, Bul. stiint., Sect. stiinte mat. si fiz. (Bucharest), **9**:1: 159 ('57). Radiological measurements of 6 springs at Singeorz-Bai (Rum.), made in '53, indicate that no appreciable change has taken place in their Rn cont. in preceding 30 yr. Reported Rn concns. vary from 0.23 to 10.9 mμc/l, Ra concns. from 8.9 to 20.87 $\times 10^{-12}$ g/l, according to source. U was found in only 1 case in trace quants. Calcareous tuffs examd. contain between 12.9 and 15.3×10^{-12} g Ra/g of tuff desiccated at 100°F, but, no measureable amts. of U. Practical method for utilization of these tuffs, available in large quants., has been previously described ('56).—*CA*

Relation Between Radon and Radium B in Some Radioactive Springs. S. Umemoto. Repts. Balneol. Lab., Okayama Univ. (Jap.), **18**:24 ('57). Signif. negative correlation was proved between Rn and Ra B cont. in spring waters of Hotel Torikai of Spa Sekigane and of Hisuinoyu of Spa Misasa. Signif. positive correlation was proved in water of Spring Gunze of Spa Misasa. Waters of 4 other springs showed no const. relation. Sources and behavior of Rn and Ra B in spring waters may be different and inconst.—*CA*

Radioactivity of the Medicinal Sulfur Waters of Goridzhvara. I. V. Aivazov. Trudy Inst. Geofiz., Akad. Nauk Gruzin. S.S.R. (USSR), **15**:103 ('56). In '53 radioactivity of the Goridzhvara medicinal S springs was measured. Samples were collected at different times. Detn. of quant. of dissolved radioactive elements in samples was made by comparison with std. prepd. with $UO_2(OAc)_2 \cdot 2H_2O$. Data show that radioactivity of mineral waters at different times of yr is almost const.—*CA*

Preparation of Sample for the Measurement of Radioactivity in Water Radioactivity in Tap and Well Water Samples in Tokyo. S. Kawamura & Y. Nozaki. Eisei Shikenjo Hokoku (Tokyo), **75**:403 ('57). To accurately det. radioactivity in tap and well water, formation of ppts. during evapn. is prevented by addn. of $5 \times 10^{-4}M$ di-Na ethylenediaminetetraacetate and also by coating vessels with silicone. Samples obtained between Oct. 24 and Dec. 7 had no signif. increase in radioactivity, though nuclear explosion could be detected by radioactivity of rain in this period. It is assumed, since there was no increase of radioactivity of ground water, that radioactive substances of rain were filtered off as it passed thru ground.—*CA*

Radioactive Springs in Japan. IV. Y. Yokoyama. Nippon Kagaku Zasshi (Tokyo), **77**:370 ('56). Ratio of thoron to randon contained in spring waters of Matsutomi Spring, Yamanashi Prefecture, was detd. indirectly by collecting Ra A, Ra B, Ra C, Th A, Th B, and Th C on charged wire put over springs. Radon cont. is inversely proportional to Tn/Rn ratio.—*CA*

Radioactivity of Some Springs on the Uludag Mountains (Turk.). S. Akpinar. Rev. fac. sci. univ. Istanbul (Turk.), **22C**: 87 ('57). Radioactivity of springs in vicinity of the physics lab. of Istanbul Univ. on Uludag Mts. (about 6,200 ft above sea level) was investigated. Rn^{222} concn. of lab. spring is $(1.46 \pm 0.15) + 10^{-10}$ c/l higher than all springs in Turk. investigated to date ('57) except Sultaniye Spring in Mugla prov. In water of lab. spring, mainly Rn^{222} has been taken up after its formation; it is not caused by dissolved Ra^{226} salts. Investigation of the β-activity of filtered-off daughter products allows est. that Rn^{220}/Rn^{222} ratio in water is smaller than 0.001. For ground exhalation in front of lab. value of 5.8×10^{-16} c/sq cm/sec was obtained.—*PHEA*

(Continued on page 90 P&R)

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(Continued from page 88 P&R)

Radioactive Impurities in Surface Waters and Their Control. W. CHRIST. Wasserwirtsch.-Wassertech. (Berlin), **7**:379 ('57). Discussion is given of radioactive decay process and origin of both natural radioactivity in water and radioactivity arising from other sources. Processes for disposing of radioactive wastes in various countries are described, as well as some tech. aspects of detg. the extent of water contamn. Those persons concerned with water purif. and supervision are encouraged to continue their efforts toward maintg. surface waters within legally prescribed tolerances.—*CA*

Public Health Implications of Radioactive Fallout in Water Supplies. H. A. THOMAS JR. Am. J. Public Health, **46**:1266 ('56). There is tendency for some who are concerned with protection of potable water supplies to attach more sanctity to stds. of max. permissible concn. of radioactivity than present knowledge would seem to warrant. In this paper assumptions underlying current stds. are elucidated. Math. model is offered in appendix.—*CA*

Radioactivity and Water-Supply Protection. O. JAAG. Gas- u. Wasserfach. (Munich), **98**:801 ('57). In thickly settled countries such as those in central Europe it is necessary to take special precautions to avoid excessive radioactivity of water supplies. Even slightly contamd. clothing, etc., and other wastes from hospitals, research insts., etc., must be segregated and stored under safe conditions. Provision for such storage has been made. Special precautions are necessary throughout Rhine Valley; otherwise radioactivity level in Holland may become excessive. This is aggravated by possible adsorption of such material when Rhine water is filtered through sand or soil for underground water enrichment in Holland.—*CA*

Radioactivity of Some Thermal Water Wells in the Regions of Oradea and Hunedoara (Rum.). A. SZABO & A. SOOS. Acad. rep. populare Romine, Bul. stiint. Sect. stiint. mat. fiz. (Bucharest), **8**:215 ('56). Survey of radioactivity of mineral waters in Rum. was continued with detn. of Rn and Ra in thermal water wells in resorts Victoria (formerly Baile Felix), 1 Mai (formerly Baile Episcopiei), both in region of Oradea, and Geoagiu in region Hunedoara. Artesian wells at Baile Victoria flow 17,000,000 l/day at 48.5°F. Water contained Rn, 0.405 mμc/l, and Ra, 3.71×10^{-12} g/l in '52. There was little change in radioactivity of these waters since '26. Thermal water wells at Baile 1 Mai have Rn cont. of 0.16–0.36 mμc/l and Ra cont. of $\sim 2.0 \times 10^{-12}$ g/l. Thermal wells at Geoagiu produce water at 30.1–32.1°F at rates of 7–700 l/min. They contain radioactivity from Rn, 0.16–3.22 mμc/l, and from Ra, $0.21–8.21 \times 10^{-12}$ g/l. Ferrous mud, used for therapeutic packings, has Ra cont. of 0.45×10^{-12} g/g (dry) at Baile Victoria, 1.1×10^{-12} g/g at Baile 1 Mai, and 3.1×10^{-12} at Geoagiu.—*CA*

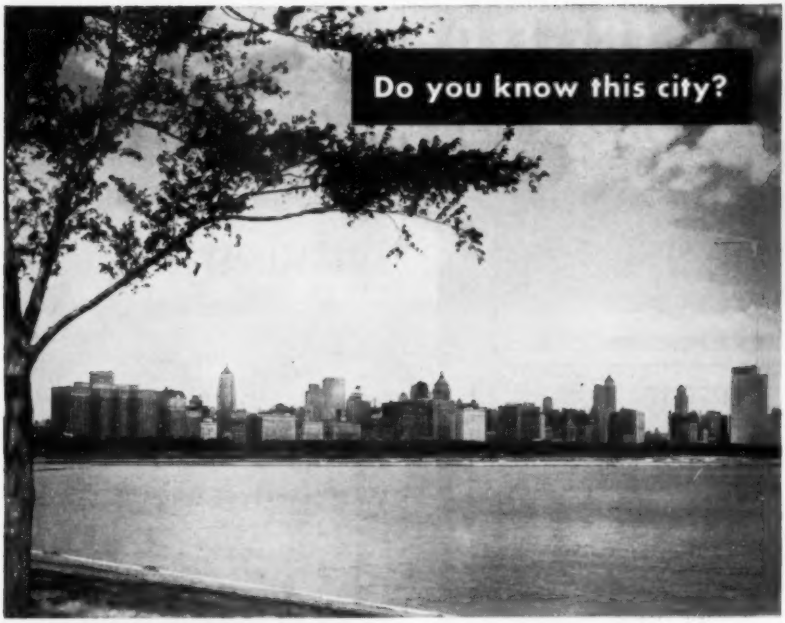
Nuclear Long-Range Fallout in Surface Waters. C. G. BELL JR. Proc. ASCE, **83**:SA5, Paper No. 1400 ('57). Graphs and conclusions are presented based on 10,000 samples taken from Mass. and vicinity of Rochester, N.Y., from Jan. '51 to Dec. '53. Rain-pptd. fallout was dialyzed through cellophane. No sedimentation was indicated in other rain samples. Avg. of most radioactive samples registered 6.9 cpm/l or 0.02 μμc/ml. —*CA*

Method of Preparing Radioactive Cations for Tracing Ground Water. W. J. LACEY & W. D. LAGUNA. Science, **124**:402 ('56). Because of adsorption in soil, use of radioisotopes for tracing flow of ground water has been limited almost entirely to iodine 131 and bromine 82, both of which, however, have very low permissible concns. in water. It has now been shown to be possible to reduce adsorption by soil of certain of normally cationic radioisotopes by chelation with Versene, tetrasodium salt of ethylenediaminetetraacetic acid. Prelim. lab. tests with cobalt 60, antimony 124, and chromium 51 have given satisfactory results. It is necessary to use as tracers metals capable of forming more strongly chelated compds. than can common cations in ground water.—*WPA*

SWIMMING POOLS

Bacteriological Standards for Bathing Waters. W. F. GARBER. Sewage and Ind. Wastes, **28**:795 ('56). Critical review is made of available bathing water bact. stds. in various communities in US and elsewhere. Case is made for using geometric mean of MPN as std. for coliform cont. in bathing water. It is relatively insensitive to extreme

(Continued on page 92 P&R)



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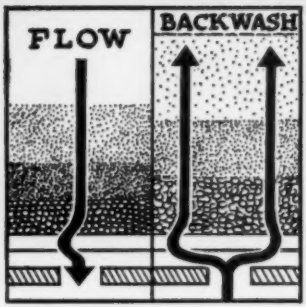

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(*Continued from page 90 P&R*)

values in series, but it is not as readily understood as arithmetic mean or % no. of samples contg. given no. of organisms. Epidemiological evidence of disease arising from bathing places pold. with sewage effluent is not strong and with present knowledge it is recommended that least stringent std. in use should be accepted provisionally. —*BH*

Learner Swimming Pool. G. M. O'Donnell & J. Green. Med. Officer (Br.), **98**: 211 ('57). There is increasing interest in practicability of bldg. simply designed small swimming pools at moderate cost, sited in schools which are far removed from, or inconvenient of access to, main swimming pool. Many authorities are now contemplating provision of these pools for learners in their primary schools. Type of pool generally envisaged is 45–50 ft in length, not exceeding 15 ft in width, and with draft of about 13 in. This paper describes such pool which was provided by Reading Cty. Borough and has been in service for past 2 yr. Pool is 24 ft long by 12 ft wide with depth of 1 ft 3 in.–1 ft 9 in. This depth can be increased when necessary for older children. Normal capac. is 2,700 gal. Most of paper is taken up with acct. of experience of chlorination by adding Chlorox by hand and controlling amt. and frequency of addns. by chem. and bact. investigations. Results were recorded in log book with data of bathing load at different times. There is good description of procedures adopted to maint. concn. of 2 ppm free chlorine. General routine which should give satisfactory results in learner pool is suggested. Experience of 2 yr is discussed and part of conclusions is that hand dosing is practical proposition and although initially it may present many difficulties with reasonable cooperation between education and public health staffs safe procedure can be evolved.—*BH*

Design of Swimming Pools. G. R. Jerus. Air Conditioning, Heating, and Ventilating, **54**:114 ('57). Good design of swimming installation requires ample facilities for bathers and proper provision for pool sanitation to elim. possible spread of skin and intestinal disorders. As safeguard most states require filing of plans and specifications in advance of constr. of public pool. This article covers details on necessary auxiliary units and common engineering computations.—*PHEA*

(*Continued on page 94 P&R*)

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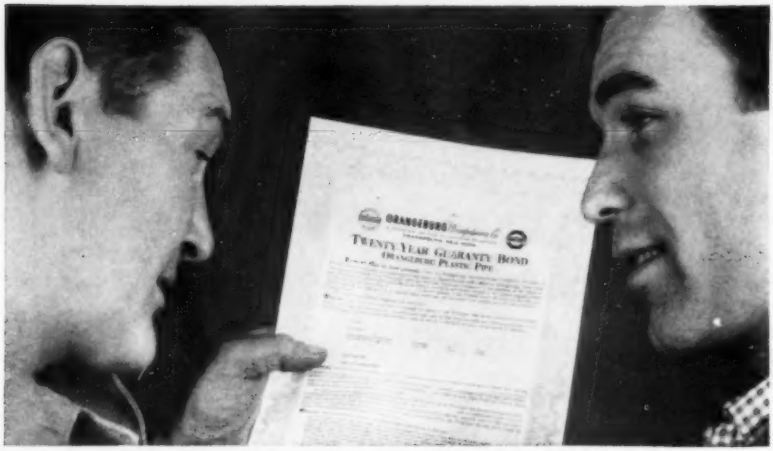

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(Continued from page 92 P&R)

Swimming Pools. A Problem in Disinfection. G. W. CAMPBELL & W. LITSKY. Sanitarian, **18**:219 ('56). Search of literature shows that regardless of which disinfectant is selected it must be accompanied by thorough and conscientious maint. of sanitary conditions at all times. Flow-through type pool is preferable to fill-and-draw type. Use of recirculated, filtered water is both economically sound, and conducive to good qual. water. Maint. of disinfectant residual is necessary to obtain contact kill, and thus prevent possibility of spread of infection by bathers using pool at same time. pH of water must be carefully controlled to prevent inactivation of disinfectant and also to prevent nuisance odors and eye irritation. pH on alk. side has been found to be most conducive to swimming comfort, and when combined with high free residual chlorine it will produce bacteriologically safe water. Valid and applicable index of poln. is necessary to det. eff. of disinfectant used and coliform index seems best fitted for this purpose.—*PHEA*

The Supervision of Swimming Pools. A. CROSS. Can. J. Public Health (Toronto), **48**:244 ('57). Some Can. prov. have regulations stating conditions under which swimming pool may be constructed and operated. Education of pool operators is one of most effective ways of reducing no. of problems encountered. Cleanliness of bathers is not emphasized sufficiently; complete replacement of pool water every 6–8 hr is recommended. Experience has shown that frequently pumps are of insufficient capac. for efficient backwashing of filters, in which case auxiliary pump should be employed. To prevent murky water max. bathing load should not be exceeded, pumps and filters should be maintd. in proper working order, and rate of flow should be not more than 3 gpm/sq ft of filter surface. Any extraneous film of dirt, oil, or grease on surface of pool can be skimmed off by raising level of pool water. Chlorine concn. and pH value should be detd. at least twice per day.—*WPA*

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Confuzion

To the Editor:

Knowing the JOURNAL's insistence on accuracy, I was surprised to read in the March issue (p. 54 P&R) that Lieutenant Waters was going to "defuse" an unexploded bomb. For your information, the lieutenant will remove a fuze and will scornfully have nothing to do with any fuse.

The reason the military people adopted the "z" spelling, so the story goes, is that when the Army once had occasion to ship a carload of explosive "fuses," the railroad insisted on charging the freight rate for electrical fuses. The Army rose to this emergency with calmness and dignity by changing the spelling, thereby getting a lower rate and saving the taxpayers a substantial amount of money, for which we are all grateful.

WILLIAM S. FOSTER
Editor, American City Magazine
New York; Mar. 30, 1959

Considering that this was a British bomb, we should have realized that a "z" would be an "s" as an "s" is always a "z," but we didn't. Excuze it pleaze.—ED.

Cl------

To the Editor:

I had occasion, in private correspondence, to approve of the NAS-NRC statement on residual chlorine in distribution systems before the statement was published in the JOURNAL (February 1959 issue, p. 230). My approval still stands. Indeed, I would go further in stating that all chemical operations in water works practice should be predicated on the demonstrated usefulness of any such operations, having in mind the nature of the raw water, the extent of water plant facilities, the nature and extent of the distribution system, and any other contributing factors.

At the Brantford, Ont., plant we have clearly demonstrated the usefulness of a combined chlorine residual in our distribution system; also we have noted that those that contributed articles to the published panel have definitely shown the usefulness of chlorine residuals in their particular operations. Thus I very much approve not only of the NAS-NRC statement, but also of the accompanying articles on the panel, including the prefatory remarks by Faber.

The main intent of this letter, however, is to prompt a useful discussion of *why* chlorine residuals, of any type, depreciate in magnitude as the water travels through the distribution system.

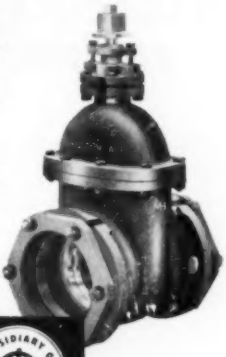
Umbenhauer states (February, p. 225): "The long use of untreated well water did not eliminate chlorine-combining substances inside the water mains." He then points out that a combined chlorine residual did not have the required persistence. From this are we to assume that his distribution system was coated by organic slimes that would react with such a residual, when it has been shown

(*Continued on page 98 P&R*)

WHAT BECAME OF TYPHOID?

Not until after 1900 (about 55 years ago) did U. S. citizens really accept public water supply systems as sources of potable water. Scientists discovered water borne disease germs in 1875. It then required about 30 years for the people to believe that such serious diseases as dysentery, cholera and typhoid fever epidemics were due to germs in their drinking water. Finally they realized that water could be clear, cold and fresh tasting, yet dangerous to drink. The water works industry therefore built treatment plants . . . sand filters and chemical feeders. The public abandoned private wells. Today, water-borne disease in America has virtually disappeared. In some 50 years, the U. S. typhoid death rate has dropped from 200 to less than 1 per 100,000 persons. Hippocrates, the "Father of Medicine", in 400 B. C., told the Greek people to boil water before drinking it, but today America's public water supplies are safe.

The water works superintendent in a real sense today is a custodian of public health and a vital force in the Nation's economy.



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(Continued from page 96 P&R)

that chloramines are not greatly affected by organic substances of the type found in water and therefore likely to be found on the inside of the mains?

Also we note that Crabill (p. 221) states that there is a definite relationship between water temperature and the persistence of chlorine residuals, a phenomenon that we have noticed in our system and have heard of frequently in other localities. I do not doubt for one instant that Crabill has shown this to be true in his system, but is it due to the greater elaboration of slime-forming organisms at higher water temperatures or to the fact that at the higher temperatures the existing chlorine residual, of any type, will more readily react with the organic substances present?

Frankly I greatly doubt that organic substances in water mains have very much to do with the disappearance of chlorine residuals, particularly those of the combined chlorine type. We went through a program of assuming slimes in the mains from the days when virtually no residual left our plant. We applied a high-level HOCl residual which we found depreciated in the mains. We had to give this type of residual up due to the accompanying NCl_3, and we changed over to a combined chlorine residual, which, even though it is more resistant to organic substances, still depreciated in our mains.

Finally we even tried copper with the chlorine-ammonia. This proved useless, but the resulting investigation showed us that the dropoff of combined chlorine

(Continued on page 100 P&R)

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WALKING BEAM FLOCCULATION EQUIPMENT

Because:

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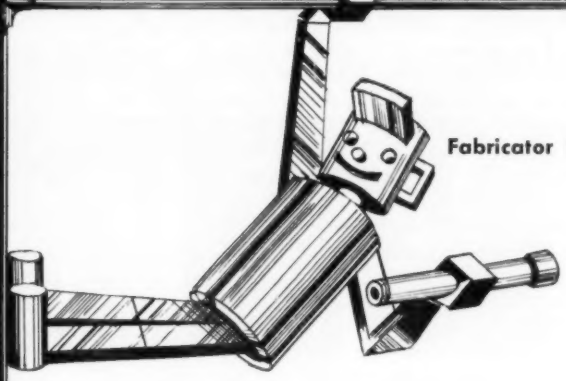

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Correspondence

(Continued from page 98 P&R)

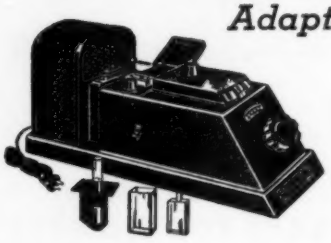
residuals in our system was caused by nothing other than ferrous iron going into solution due to the incipient corrosion. Indeed, ferrous iron is one of the best dechlorinants known. Our entire work in this regard is detailed in "Dechlorination Linked to Corrosion in Water Distribution Systems" (*Water & Sewage Works*, March 1953), to which the writer refers those interested.

Surely our distribution system is not the only one where traces of ferrous iron dechlorinate a chlorine residual? I would particularly like to see some remarks on the stability of chlorine residuals from those whose finished water is not corrosive and has a slightly positive saturation index. Even in noncorrosive waters will some traces of iron go into solution to act as a dechlorinant? It would be of interest to hear from operators of systems where community expansion has resulted in large areas in which asbestos-cement or cement-lined cast-iron mains have been installed, the residuals in which could be compared to those in the same water in all-iron piping.

Not the slightest hint of criticism is to be inferred from this letter. I applaud the efforts of those who contributed to the panel, but I still ask: May we have some discussion in these "Correspondence" columns on why various types of chlorine residuals depreciate in various distribution systems on this continent?

D. B. Williams
Water Works Chemist, Public Utilities Com.
Brantford, Ont.; Feb. 27, 1959

KLETT SUMMERSON
ELECTRIC PHOTOMETER



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4-man crew lays 1500 feet a day of CLOW 8" Bell-Tite Joint cast iron pipe through Florida swampland—often in 3 feet of water. Hancock Pipe Co., Clearwater, Fla., contractor.

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Despite rocky terrain and digging through 2 to 3 feet of frost, workers were able to lay 50% as much 12" Bell-Tite pipe a day at 14 below zero as under normal conditions. Trench was 11 feet deep. Nels Nelson & Sons, Duluth, Minn., contractors.

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PROVED...

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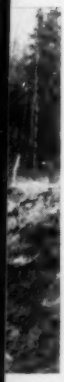

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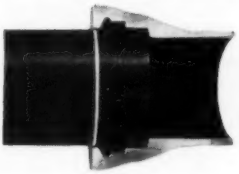

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Service Lines

Flocculating equipment and settling tanks are among the items described in a new 64-page illustrated booklet. Catalog 952 is available by writing the Advertising Dept., Jeffrey Mfg. Co., Columbus 16, Ohio.

Ductile-iron products are discussed in a new 36-page, two-color catalog that gives technical information and applications of this material. The catalog, titled "American Ductile Iron," may be obtained from American Cast Iron Pipe Co., Box 2603, Birmingham 2, Ala.

Automatic analyzers, designed for continuous chemical analysis, are the subject of an 8-page, three-color brochure. Designed for accuracy within 1 per cent, the Technicon AutoAnalyzer system is illustrated and described in detail. The booklet is available from Technicon Controls, Inc., Chauncey, N.Y.

Concrete production is discussed in a 6-page, two-color bulletin that analyzes the nine vital factors governing the production of high-quality concrete. Illustrated with charts and graphs, Bulletin P-36B may be obtained from Master Builders Co., Cleveland 3, Ohio.

Pipe cutters designed for use in trenches and other small areas are described in a 4-page, two-color bulletin. Complete with illustrations and parts list, Catalog No. 41 is available from Ellis & Ford Mfg. Co., Box 308, Birmingham, Mich.

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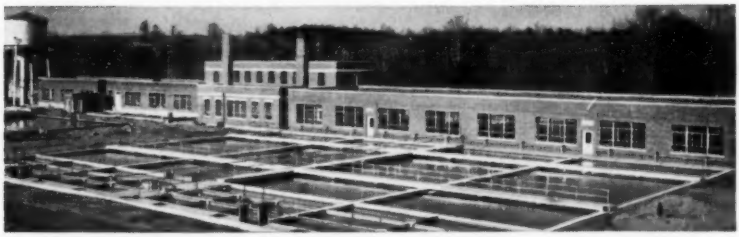

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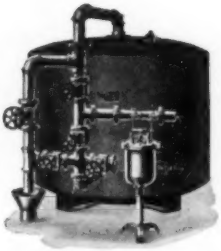

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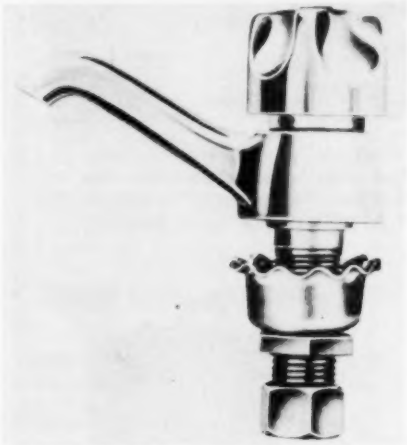
SWIMMING POOL EQUIPMENT

This modern pool at Levittown, Pa., built by Levitt and Sons, Inc., is representative of the thousands of Roberts-equipped swimming pools. We produce a complete line of swimming pool recirculating plants and filtration equipment, backed by more than 60 years experience in the field of water purification.

(Continued from page 52 P&R)

A brand new faucet, based on a novel, patented principle, has been introduced on the market by Kel-Win Mfg. Co., 3021 W. Clay St., Richmond 30, Va. The Kel-Win Self-Seating Faucet operates by a cam and straight-lift piston action. Unlike the spring-loaded faucet that snaps shut when released, the Kel-Win faucet remains open at any desired water flow, leaving both hands free. The user starts the closing operation by hand but, before a half-turn is accomplished manually,



a spring takes over and, at the same time, water pressure pushing up against the bottom of the valve in the direction of closing helps seat it. Maintenance-free service and absence of leakage are among the advantages claimed.

Louis B. Harrison has retired as superintendent of filtration at Bay City, Mich., after 43 years of service in the water works field. A former chairman and Fuller Award nominee of the Michigan Section, Mr. Harrison was instrumental in the building of Bay City's filtration and sewage treatment plants. His successor is James Hornung, superintendent of water supply at Holland, Mich.

Fluorinews, which has been dropping off of late, with only 131 new fluoridation programs in 1958, compared with 378 in 1953, still contributes an occasional item of interest:

- One such was a new call to action by Arthur Flemming, secretary of health, education, and welfare, during National Dental Health Week, urging a "militant majority" to combat the "militant minority" that is blocking water fluoridation in many cities. The fact that only one of four people in the US drinks water fluoridated to prevent dental decay, said Secretary Flemming, "is nothing short of tragic."
- It was just after Dental Health Week that mention in the story of President Eisenhower's goodwill mission to Mexico of his use of bottled water brought antifluoridationist claims that he did so to avoid fluoridated water and strong enough Hagerty denials to remind us that the controversy isn't over.
- Last month we saw our first copy of a bulletin entitled *Fluoridation for Your Community,* prepared by the AFL–CIO Community Service Activities group, and were especially happy to note its approach:

> Is it possible to make a really good thing better?
>
> The answer to this question is "yes" when it comes to improving one of nature's greatest gifts—water.
>
> Most American communities are justifiably proud of their safe, abundant water supply. . . .

(Continued on page 108 P&R)

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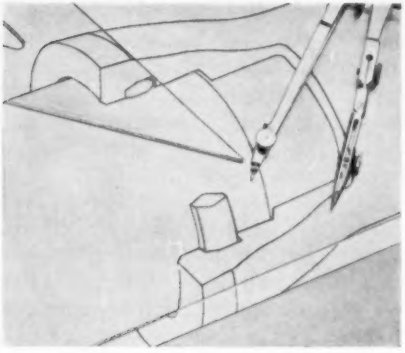

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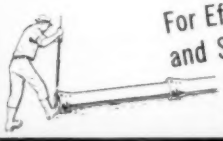

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Wipe on a small amount of special lubricant—This reduces friction.

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Insert plain beveled end of pipe — there are no grooves, ridges or tips on gasket to interfere with smooth insertion.

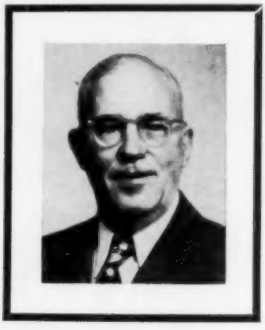
Small amount of pressure required to force plain end to bottom of socket—Your simple, time saving joint is completed.

(Continued from page 106 P&R)

• Last month, too, we noted the report of a statement by Dr. Watson Kirconnell, president of Acadia University, Wolfville, N.S., giving credence to a claim that fluoridation resulted in damage to the brain tissue and that the real purpose behind it is to lower the resistance of the masses to domination and loss of liberty.

• And last month the Brooklyn and Queens members of the Greater New York Committee Opposed to Fluoridation, Inc., renewed the drive to block fluoridation of New York City's supply, asserting that the governments of Sweden and Ontario had both rejected moves to fluoridate their supplies.

Some 1,500 communities later, this is where we came in.



Victor M. Ehlers, director of the Div. of Sanitary Engineering, Texas Dept. of Health, died Mar. 20, 1959, at the age of 74. Born in Bastrop County, Tex., in 1884, he was graduated from Texas A&M College in 1905 with a B.S. in civil engineering. He began his career by working for a number of railroads, was president of Coastal Water & Sewer Construction Co., and served as consulting engineer on various water and sewerage projects. In 1915 he accepted the position of chief sanitary engineer (later director) of the Texas Dept. of Health, a post he held until his death. He contributed greatly to the expansion of sanitary engineering programs in the state and was internationally noted as a consultant.

A Life Member of AWWA (joined in 1927), he received the Fuller Award on nomination by the Southwest Section in 1941. In 1958 he was made an Honorary Member of AWWA. Mr. Ehlers also belonged to, and was honored by, many other professional organizations, including APHA (vice-president), CSSE (chairman), ASCE, FSIWA (president), Texas Water & Sewage Works Assn. (secretary), and Institute of Inter-American Affairs.

Lawrence A. Moll, safety supervisor for the Seattle, Wash., Water Dept., died Mar. 3, 1959. Responsible for the development of the department's safety program, he was active in safety and civil defense matters throughout the state.

Employment Information

Classified ads will be accepted only for "Positions Available" or "Position Wanted." Rate: $1.50 per line (minimum $5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

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WATER SUPERINTENDENT. The village of La Grange, Illinois, is seeking applications for the position of Water Superintendent. Will have charge of complete water works system, including treatment and distribution. 3-mgd plant. Lime-soda ash-zeolite softening process. Salary open. Attractive fringe benefits. Apply, submitting resume of education and experience, to Robert E. Meyer, Village Manager, La Grange, Illinois.

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Advanced Design

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NEW,

EXCLUSIVE

"UNI-WEDGE"

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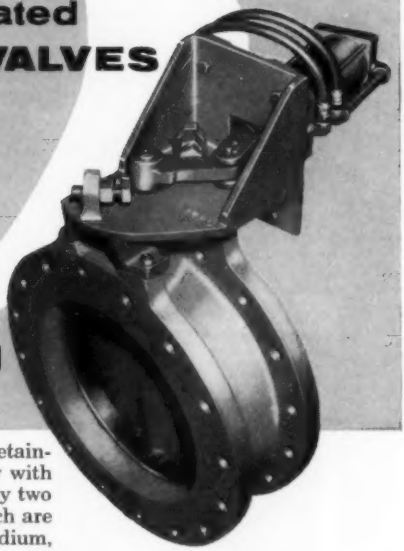

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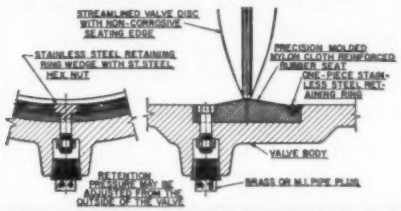
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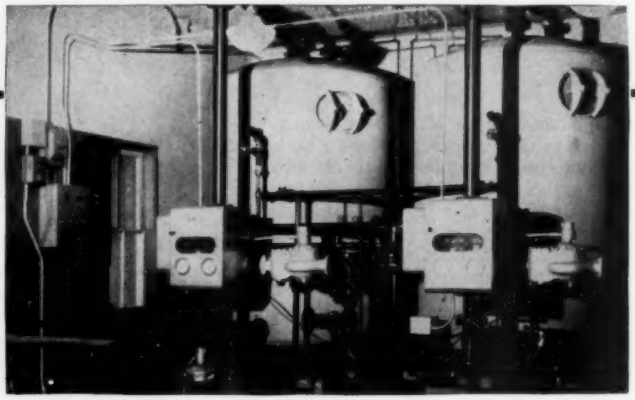

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Premium quality, American Molox is designed with an integrally cast socket and cast steel glands for maximum strength and large diameter stainless steel bolting for corrosion resistance.

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Permutit Co.

Ferric Sulfate:
Tennessee Corp.

Filter Materials:
Anthracite Equipment Corp.
Carborundum Co.
Dicalite Div.
General Filter Co.
Johns-Manville Corp.
Monterey Sand Co.
Northern Gravel Co.
Permutit Co.
Stuart Corp.

Filters, incl. Feedwater:
B-I-F Industries, Inc.—Proportioneers
Dorr-Oliver Inc.
Graver Water Conditioning Co.
Permutit Co.
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.

Filtration Plant Equipment:
B-I-F Industries, Inc.—Builders
B-I-F Industries, Inc.—Omega
Chain Belt Co.
Cochrane Corp.
Filtration Equipment Corp.
General Filter Co.
Golden-Anderson Valve Specialty Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
F. B. Leopold Co.
Permutit Co.
Roberts Filter Mfg. Co.
Simplex Valve & Meter Co.
Stuart Corp.
Wallace & Tiernan Inc.

Fittings, Copper Pipe:
Dresser Mfg. Div.
Hays Mfg. Co.
Mueller Co.

Fittings, Tees, Ells, etc.:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
M & H Valve & Fittings Co.
Morgan Steel Products, Inc.
Southern Pipe & Casing Co.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Flocculating Equipment:
Chain Belt Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
F. B. Leopold Co.
Permutit Co.
Stuart Corp.

Fluoride Chemicals:
American Agricultural Chemical Co.
Olin Mathieson Chemical Corp.
Tennessee Corp.

Fluoride Feeders:
B-I-F Industries, Inc.—Omega
B-I-F Industries, Inc.—Proportioneers
Wallace & Tiernan Co., Inc.

Furnaces:
Jos. G. Pollard Co., Inc.

Gages, Liquid Level:
B-I-F Industries, Inc.—Builders
Simplex Valve & Meter Co.
Sparling Meter Co.
Wallace & Tiernan Inc.

Gages, Loss of Head, Pressure of Vacuum, Rate of Flow, Sand Expansion:
B-I-F Industries, Inc.—Builders
Foxboro Co.
Jos. G. Pollard Co., Inc.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Gasholders:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:
James B. Clow & Sons
Johns-Manville Corp.

Gates, Shear and Sluice:
Armco Drainage & Metal Products, Inc.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Mueller Co.
R. D. Wood Co.

Gears, Speed Reducing:
DeLaval Steam Turbine Co.
Worthington Corp.

Glass Standards—Colorimetric Analysis Equipment:
Klett Mfg. Co.
Wallace & Tiernan Inc.

Goosenecks (with or without Corporation Stops):
James B. Clow & Sons
Mueller Co.
Southern Pipe & Casing Co.

Hydrants:
James B. Clow & Sons
Darling Valve & Mfg. Co.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
Photovolt Corp.
W. A. Taylor & Co.
Wallace & Tiernan Inc.

Hypochlorite; see Calcium Hypochlorite; Sodium Hypochlorite

Ion Exchange Materials:
Chemical Process Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
National Aluminate Corp.
Permutit Co.
Roberts Filter Mfg. Co.
Rohm & Haas Co.

Iron, Pig:
Woodward Iron Co.

Iron Removal Plants:
American Well Works
Chain Belt Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Jointing Materials:
Johns-Manville Corp.
Keasbey & Mattison Co.
Leadite Co., Inc.

Joints, Mechanical, Pipe:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
Southern Pipe & Casing Co.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Leak Detectors:
Aqua Survey & Instrument Co.
Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:
B-I-F Industries, Inc.—Omega
Dorr-Oliver Inc.
General Filter Co.
Infilco Inc.
Permutit Co.
Wallace & Tiernan Inc.

Locators, Pipe & Valve Box:
Aqua Survey & Instrument Co.
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Magnetic Dipping Needles:
Aqua Survey & Instrument Co.
W. S. Darley & Co.

Meter Boxes:
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.

NON-STOP FILTERING

even when backwashing GFC Multi-Cell Filters

There's no time lost when backwashing GFC Multi-Cell Filters. While one cell is being backwashed, the other cells provide: **(a)** Water for backwashing that cell **with or without** the use of storage tanks or surface reservoirs. **(b)** Uninterrupted filtering to maintain a continuous flow to service lines. Other important features include low-cost installation and GFC's patented non-clogging "Multi-Plate" underdrains. Write for bulletins and equipment data.

GENERAL FILTER CO.

WATER PROCESS EQUIPMENT AMES, IOWA

AERATORS • FILTERS • SOFTENERS • CLARIFIERS
FLASH MIXERS • FLOCCULATORS • PNEUMATIC CONTROLS
ROTARY DISTRIBUTORS • SLUDGE SCRAPERS

Ford Meter Box Co.
Gamon Meter Div., Worthington Corp.
Hays Mfg. Co.
Hersey Mfg. Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Calmet Meter Div., Worthington Corp.
Gamon Meter Div., Worthington Corp.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Filtration Plant, Pumping Station, Transmission Line:
B-I-F Industries, Inc.—Builders
Foster Eng. Co.
Simplex Valve & Meter Co.
Sparling Meter Co.

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
B-I-F Industries, Inc.—Builders
Buffalo Meter Co.
Burgess-Manning Co., Penn Instruments Div.
Calmet Meter Div., Worthington Corp.
Gamon Meter Div., Worthington Corp.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Sparling Meter Co.

Mixing Equipment:
Chain Belt Co.
General Filter Co.
F. B. Leopold Co.

Paints:
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
Alabama Pipe Co.
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Southern Pipe & Casing Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.
Vulcan Materials Co.

Pipe, Copper:
American Brass Co.

Pipe, Plastic:
Morgan Steel Products, Inc.
Orangeburg Mfg. Co.

Pipe, Steel:
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.
Morgan Steel Products, Inc.
Southern Pipe & Casing Co.

Pipe Cleaning Services:
National Water Main Cleaning Co.

Pipe Coatings and Linings:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
Centriline Corp.
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.
Reilly Tar & Chemical Corp.
Southern Pipe & Casing Co.

Pipe Cutters:
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
E. H. Wachs Co.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators; see Locators, Pipe

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potassium Permanganate:
Carus Chemical Co.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Chemical Feed:
B-I-F Industries, Inc.—Proportioneers
Precision Chemical Pump Corp.
Wallace & Tiernan Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.
Peerless Pump Div.

Pumps, Diaphragm:
Dorr-Oliver Inc.
W. S. Rockwell Co.
Wallace & Tiernan Inc.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Peerless Pump Div.
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Sump:
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Fiese & Firstenberger
Layne & Bowler, Inc.
Peerless Pump Div.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Inc.

Recording Instruments:
B-I-F Industries, Inc.—Builders
Simplex Valve & Meter Co.
Sparling Meter Co.
Wallace & Tiernan Inc.

Reservoirs, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves: see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
Permutit Co.

Sodium Aluminate:
National Aluminate Corp.

Sodium Chloride:
International Salt Co., Inc.

Sodium Fluoride:
American Agricultural Chemical Co.

Sodium Hexametaphosphate:
Calgon Co.

Sodium Hypochlorite:
Jones Chemicals, Inc.
Wallace & Tiernan Inc.

Sodium Silicate:
Philadelphia Quartz Co.

Sodium Silicofluoride:
American Agricultural Chemical Co.
Tennessee Corp.

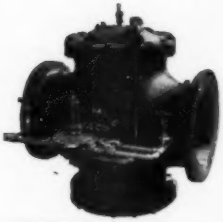
Softeners:
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon Co.
General Filter Co.
International Salt Co., Inc.
National Aluminate Corp.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.

1879—ROSS—1879

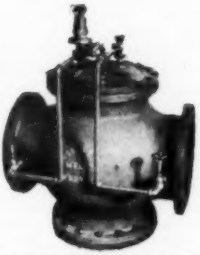
Automatic Valves



ALTITUDE VALVE

Controls elevation of water in tanks, basins and reservoirs

1. Single Acting
2. Double Acting



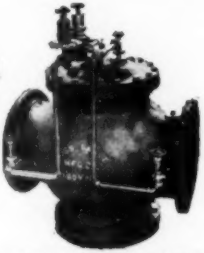
SURGE-RELIEF VALVE

Maintains safe operating pressures for conduits, distribution and pump discharge

REDUCING VALVE

Maintains desired discharge pressure regardless of change in rate of flow

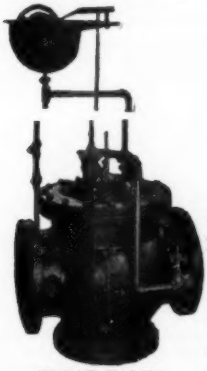
Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.



COMBINATION VALVE

A self contained unit with three or more automatic controls

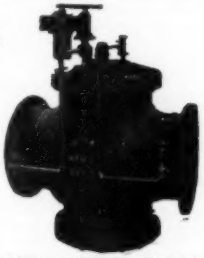
Combination automatic control both directions through the valve.



FLOAT VALVE

Maintains levels in tank, reservoir or basin

1. As direct acting
2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.



REMOTE CONTROL VALVE

Electric remote control—solenoid or motor can be furnished

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

Packing Replacements for all Ross Valves Through Top of Valve

ROSS VALVE MFG. CO., INC., P. O. BOX 593, TROY, N.Y.

Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Morgan Steel Products, Inc.
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Ford Meter Box Co.
Hays Mfg. Co.
Mueller Co.

Storage Tanks: see Tanks

Strainers, Suction:
James B. Clow & Sons
R. D. Wood Co.

Surface Wash Equipment:
Golden-Anderson Valve Specialty Co.
Permutit Co.

Swimming Pool Sterilization:
B-I-F Industries, Inc.—Builders
B-I-F Industries, Inc.—Omega
B-I-F Industries, Inc.—Proportioneers
Wallace & Tiernan Inc.

Tanks, Prestressed Concrete:
Preload Co., Inc.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Morgan Steel Products, Inc.
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
B-I-F Industries, Inc.—Builders
B-I-F Industries, Inc.—Proportioneers
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Permutit Co.
Wallace & Tiernan Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
W. S. Rockwell Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Allis-Chalmers Mfg. Co., Hydraulic Div.
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
B-I-F Industries, Inc.—Builders
Simplex Valve & Meter Co.

Waterproofing:
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.

Water Softening Plants: see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
LaMotte Chem. Products Co.
W. A. Taylor & Co.
Wallace & Tiernan Inc.

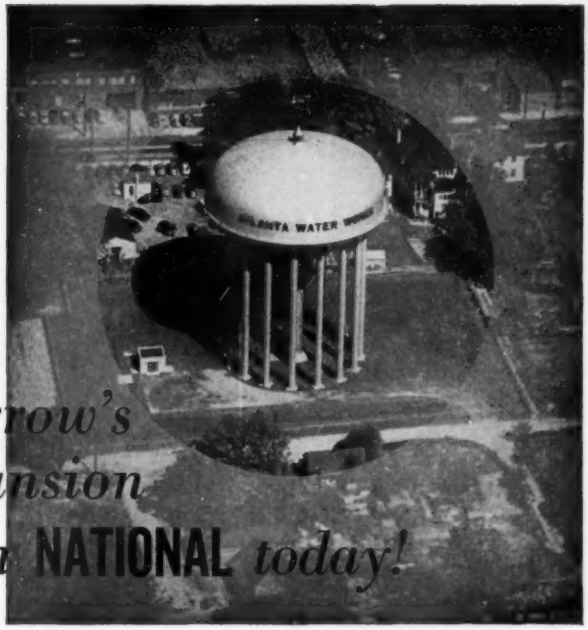
Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1957 AWWA Directory.



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Like Atlanta, Ga., *you* too can meet tomorrow's increased water demands with *clean water mains.* When the coefficient of sections of Atlanta's 45 year old main dropped to a low of 44, Waterworks General Manager, Paul Weir ordered National cleaning. Results were outstanding. Water pressure and capacity doubled, giving better fire protection and higher water pressure to outlying sections.

Do as other leading cities have done—let *National* cleaning provide for tomorrow's expansion without capital expenditure today! We can prove that National cleaning is an investment—not an expense.

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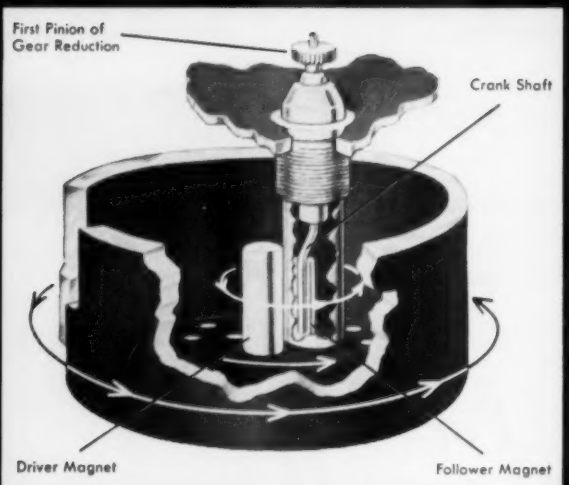

THE POWERFUL PULL OF A PERMANENT MAGNETIC DRIVE

In the Rockwell Sealed Register meter the register is driven by a powerful magnetic coupling of Alnico alloy. This construction eliminates the need for a stuffing box. It permits the register and all reduction gearing to operate in a hermetically sealed chamber high and dry above the flowing stream. With a sealed barrier against dirt and corrosion, lighter instrument type gears and pinions can be employed which reduce the drag on the measuring chamber and thereby improve meter accuracy and response.

The magnetic drive itself is fully shielded to prevent "cheating." And its powerful magnetic force is good for a lifetime of operation. For descriptive bulletin write Rockwell Manufacturing Co., Pittsburgh 8, Pa.

SEALED REGISTER METERS

another fine product by

ROCKWELL

EDMONTON, ALBERTA

solves turbidity removal and softening problems in enlarged 40 MGD water treatment plant

Meeting the needs of its phenomenal population and industrial growth over the past decade, Edmonton has now almost tripled the capacity of its modern water treatment plant.

The original installation, incorporating the most modern lime-soda plant in Canada, went into operation in 1948 to supply 15 MGD. Dorrco Flocculators, followed by Dorrco Squarex Clarifiers, were employed to remove hardness, turbidity and color in two stages, each followed by carbonation. Addition of two sets of Flocculators and two 150′ Squarex Clarifiers now provides the Edmonton plant with a capacity for handling 40 MGD.

This new equipment was supplied by our Canadian associate, Dorr-Oliver-Long, Limited. The choice is a tribute to the excellent performance of the original installation in treating water showing 1,800 ppm turbidity, 360 ppm color and 325 ppm hardness, all of which are reduced in accordance with the high standards set for civic water supplies.

For information on the complete line of Dorr-Oliver equipment for water works installations, write to Dorr-Oliver Incorporated, Stamford, Connecticut.

Consulting Engineers on Concrete Design: Kastern, Longworth and Associates Limited, Edmonton, Alberta.

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